AIR FORCE RESEARCH LABORATORY
TECHNOLOGY MILESTONES
A Review of 2005

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14. ABSTRACT

AFRL Technology Milestones highlight significant scientific and technical accomplishments for visually-coupled acquisition and targeting systems for our warfighter to automatic spoken language translators for our international warriors. AFRL, headquartered at Wright-Patterson AFB, Ohio is the Air Force's largest employer of scientist and engineers, with partnerships in industry and academia, working to develop and transition affordable integrated technologies to support a broad range of future capabilities. This Technology Milestones book includes stories from the following categories: Support to the Warfighter; Sustainment; Emerging Technologies; Technology Transfer; and Awards Recognition.

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AFRL
Technology Milestones Program

Helping to maintain the Air Force's strong Science and Technology foundation one milestone at a time.

The Air Force Research Laboratory is a tremendously important and exciting organization represented by exceptional people, all dedicated to envisioning solutions and delivering the "art of the possible" to the warfighter.

Our mission is to lead the discovery, development, and integration of affordable warfighting technologies for our air and space forces. We execute our mission through our nine technology directorates located throughout the United States, our Air Force Office of Scientific Research, and our central staff.

Innovation and technology are key components of the Air Force's strong foundation. The imagination of the world's best and brightest minds—in government, industry, and academia—ultimately delivers the equipment, weapon systems, and ideas driving our organization. These technology milestones showcase some of the technological advancements accomplished within AFRL.

Headquartered at Wright-Patterson Air Force Base Ohio, AFRL is the Air Force's largest employer of scientists and engineers. In a population of about 3,400, approximately 23% have doctorate degrees in science and engineering disciplines.

The laboratory's research spans the full spectrum of science and technology—from conducting basic research to launching experimental microsatellites. Our scientists and engineers create technologies today that will be used by the nation's air and space forces of tomorrow.

You will find in these pages some of our most noteworthy technology milestones for 2005. These stories are just a sample of the AFRL technologies currently under development.

For more information about a Technology Milestone, please contact our technology clearinghouse, TECH CONNECT, at 800-203-6451, and a team member will direct you to the appropriate laboratory expert.

You can also visit our Web site at **www.afrl.af.mil**.

Introduction

The Air Force Science and Technology Milestones herein often represent the combined effort of several scientists and engineers working as a team. The basic and applied research, plus the follow-on technology development described, are essential to the continued success of the Air Force mission.

Technology Milestones were selected from one or more of the following categories:

Support to the Warfighter (Air, Space and Cyberspace)

Technology that has potential for or has achieved application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations.

Sustainment (Air and Cyberspace)

Technology to increase readiness and reduce life cycle costs of legacy systems, applicable to (1) Base infrastructure, (2) Maintenance, (3) Logistics, (4) Training, and (5) Human performance.

Emerging Technologies

Major innovative technological advancements that offer significant potential for existing and future Air Force systems.

Technology Transfer

Technology that has transferred from the laboratory to the private sector, to include industry, academia, and state and local governments.

Awards and Recognition

Awards and recognition by the scientific community at large, concerning technology advancements in the areas of technology transition, technology transfer, or technical achievement.

Support to the Warfighter

Page

Air

Space

Cyberspace

High-Frequency Acoustic System

Payoff

Scientists created the High-Frequency Acoustic Suppression Technology (HiFAST) airflow control device to replace the spoilers traditionally used to reduce acoustic resonance created by opening weapons bay doors at high speeds. HiFAST is a second-generation device that requires less flow than the first-generation, active separation control device. By injecting air through nozzles at the front of an aircraft's weapons bay, the HiFAST device effectively reduces weapons bay acoustics and aids in safe weapons separation without using any moving parts or extending past the surface of the air vehicle.

Accomplishment

AFRL successfully completed the first flight test of the HiFAST flow control device under a cooperative research effort between Australia and the US. For the flight test, engineers fitted HiFAST onto a Royal Australian Air Force F-111. While the F-111 flew at subsonic, transonic, and supersonic speeds, scientists collected acoustic, thermal, and vibration data from instrumentation placed throughout the aircraft's weapons bay. Additionally, the team collected data during release of the Powered Low-Cost Autonomous Attack System subpack munitions, also developed by AFRL. Throughout testing, HiFAST successfully reduced the acoustic noise levels in the open weapons bay.

Background

The HiFAST device is located within the leading edge of the aircraft weapons bay and can be controlled by the flight engineer or pilot during flight. It contains nozzles that inject the airstream with pulses of supersonic high-pressure air, which counters airflow instabilities generated by opening a weapons bay door. Without HiFAST, opening weapons bay doors during flight creates a highly unstable shear layer—an area where airflow transitions sharply from the high-speed airflow outside the weapons bay to slower-speed airflow within the bay. This condition results in unstable pockets of circularly rotating air, called vortices, which hit the weapons bay walls and generate acoustic waves. These acoustic waves flow back up the airstream and cause acoustic resonance, which produces strong vibrations that may damage the aircraft, its systems, and the weapons it carries.

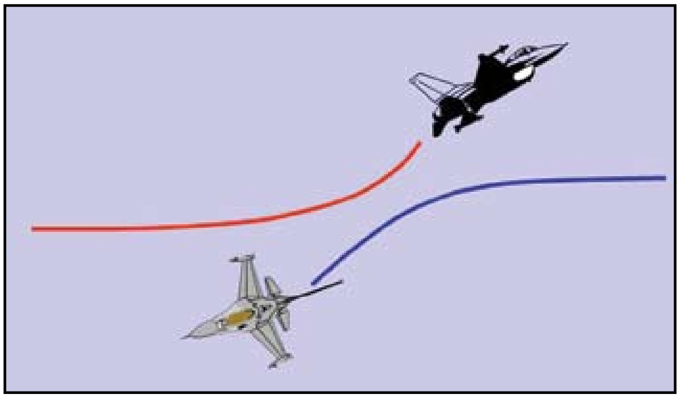
AFRL Completes First Automatic Air Collision Avoidance System

Payoff

The Automatic Air Collision Avoidance System (Auto ACAS) uses linked navigational data and sensor data to detect imminent collision and automatically steer an aircraft evasively. Potentially, it could save the Air Force (AF) millions of dollars in air vehicle losses.

Accomplishment

AFRL partnered with the Swedish government to successfully complete Auto ACAS. Other organizations involved in developing and testing Auto ACAS included the Air Force Flight Test Center, Bihrle Applied Research, Boeing, Lockheed Martin, the National Aeronautics and Space Administration, General Dynamics, Saab, and the US Air Force Test Pilot School. Through four flight test demonstrations, this new collision avoidance system proved effective in collision prevention without relying upon pilot input. During the first three flight demonstrations, an F-16 with Auto ACAS was data-linked to a ground computer simulating a second F-16.



Auto ACAS successfully steered the piloted F-16 away from a collision with the virtual aircraft. This method of testing Auto ACAS enabled engineers to collect large amounts of data, while using less fuel, increasing flight test safety, and decreasing the time required to set up each test run. During the fourth flight demonstration, Auto ACAS used data link information between two piloted F-16 aircraft, both outfitted with Auto ACAS, to prevent a collision. Auto ACAS also used inputs from an F-16's radar to steer it clear of a collision with a second F-16 not equipped with Auto ACAS.

AFRL engineers are studying the integration of Auto ACAS with the previously developed Automatic Ground Collision Avoidance System. The resulting system would provide collision safety for many different air and ground collision scenarios. Cost analysis shows that retrofitting this combined collision avoidance system into various aircraft could save the AF hundreds of millions of dollars in aircraft losses. Lockheed Martin engineers are studying the costs and processes related to integration of this combined collision avoidance system into the F-35 Joint Strike Fighter design.

Background

Midair collisions are a major cause of AF fighter aircraft loss. Prior to Auto ACAS, collision avoidance systems provided audio and visual guidance to pilots but still required manual action. Such warnings worked well for slow-maneuvering transport aircraft but were ineffective for fighter aircraft, whose mission requires close-formation flying and aggressive maneuvering in the vicinity of other aircraft. Auto ACAS solves this problem. It takes control after the pilot has missed the chance to avoid a collision manually, performs an aggressive maneuver to avoid the collision, and then returns control to the pilot.

AFRL Tests Antenna Radar Dome Materials for Navy

Payoff

AFRL used its unique in-house capabilities to provide critical experimental validation for the US Navy Surface Warfare Center. This technology is of interest to all of the services, including the Air Force.

Accomplishment

AFRL engineers used the laboratory's Aerospace Structures Research Facility to evaluate numerous composite material samples for the Navy. The Navy may use these samples for the radar dome of its DD(X) ship concept. Engineers exposed the samples to high-energy pulses to determine their resistance to thermal threats. Raytheon, the contractor responsible for sample development, will use the experimental results to develop radar that is resistant to battle damage.

Background

The DD(X) is the Navy's next-generation destroyer. This multimission platform will conduct precision strike and fire support, dominate coastal regions, and respond to difficult threats. Survivability is a major DD(X) requirement, and a radar dome capable of protecting the ship's radar from thermal threats is vital to satisfying this requirement.

AFRL's Aerospace Structures Research Facility is the largest combined-environment experimental facility in the world. It provides state-of-the-art validation capabilities to all government agencies, as well as industry and academia through Cooperative Research and Development Agreements.

AFRL Evaluates Rapid Prototyping Technologies for Aerodynamic Research

Payoff

In the past, engineers needed months to manufacture aircraft models for experimental research in ground testing facilities. Recent innovations in rapid prototyping (RP) technology make it possible to produce models in weeks or even days, depending upon model complexity. By permitting concurrent studies of new technology concepts in wind tunnels and through computer simulation, this capability generates a faster, better response to warfighter needs.

Accomplishment

AFRL evaluated industry's recent advancements in materials research to determine if any off-the-shelf RP materials could meet the requirements of rapid aerodynamic technology assessment. This approach is substantially faster and less expensive than initiating an in-house research and development effort to create new RP materials.

During their initial search, AFRL engineers identified nine RP materials that could potentially meet requirements for fabrication of models used in wind tunnel experiments. These materials included six stereolithography materials and three stainless steel and bronze (i.e., metal)-sintered materials. During a series of tests, AFRL collected tensile, bending, bearing, and melting temperature data on the materials and discovered two of the stereolithography materials and one of the metal-sintered materials met all requirements.

Background

Stereolithography is an RP technology that uses a laser beam to produce a model by building plastic parts layer by layer from a container of liquid photopolymer. The laser solidifies the photopolymer and eventually completes a three-dimensional (3-D) model. Laser sintering is an RP technique that uses a high-powered laser to fuse together small particles of plastic, metal, or ceramic powders into a 3-D form.

AFRL Develops Aircraft Countermeasures Laser System

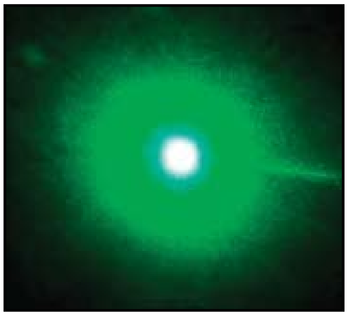
Payoff

The Aircraft Countermeasures (ACCM) system, used in conjunction with helicopter gunnery, can potentially destroy or disrupt the aim of ground troops firing small arms at the helicopter. Because manufacturers do not design modern aircraft for precise engagement of dismounted adversaries in and around isolated friendly personnel and vehicles, a gap exists in potential weapons engagement zones. The ACCM closes that gap, using laser light to disorient adversaries and disrupt their ability to engage.

Accomplishment

To predict the ACCM laser system's effectiveness under different ambient illuminations and at different ranges, AFRL scientists modeled the possible glare and loss of visual sensitivity effects resulting from its use. They compared these modeled predictions to the data and measurements taken during a non-live-fire test conducted at Kirtland Air Force Base, New Mexico, in 2004.

The objective of the non-live-fire field test was to document the ACCM laser's effect on human visual performance during a ground, static field test. AFRL scientists designed this initiative to determine whether the ACCM device provided a credible glare source at respective ranges of 100 m and 340 m, and whether the glare significantly lowered the visual performance of an individual performing the task of aiming a rifle.



AFRL and Air Force Special Operations Command (AFSOC) recently conducted a technology demonstration using a prototype laser and lens that tested three laser conditions and two ranges against security forces personnel tactically advancing the target. Analyzing the distribution of "bullet hits" showed that all tested laser-on conditions were more effective gunfire deterrents than laser-off/ nonlaser conditions provided. Shooter performance did decrease while the shooter was illuminated by the laser.

Background

The ACCM system comprises a nonlethal laser device mounted coaxially to allow the gunner both side-to-side and tail ramp firing of the weapon. While ACCM use encompasses many nonmilitary applications, the purpose of the ACCM program is to repackage the system for military operations.

Future variants of the system may be applicable to other platforms or missions. The Personnel Recovery Extraction Survivability with Smart Sensors technology demonstration originally funded part of the ACCM prototype's development. In August 2003, Air Combat Command and AFSOC initiated a warfighter rapid acquisition program to accelerate the effort.

AFRL Supports the Navy's Aegis Ballistic Missile Defense Program

Payoff

Acquiring, tracking, and collecting critical missile launch data paves the way for successful missile defense programs such as the Navy's Aegis Ballistic Missile Defense (BMD) effort. Closed-loop tracking of a ballistic target interception/impact is a very important aspect of missile defense program success.

Accomplishment

AFRL scientists and engineers used the 3.6 m, 1.6 m, and 1.2 m telescopes housed at the Air Force Maui Optical and Supercomputing (AMOS) site to acquire, track, and collect critical data during the latest series of launches from the Pacific Missile Range Facility (PMRF) in support of the Navy's Aegis BMD program. The latest launch mission, known as the Stellar Dragon Campaign, spanned nearly a month and comprised five missile launches from the PMRF.

After completing over 25 days of dry run and mission support, AFRL's AMOS team successfully collected data on all mounts and sensors during the Stellar Dragon Campaign. Only one mission was limited during this critical data collection process (due to inclement weather).

Along with employing numerous resident sensors, AFRL's AMOS team members integrated three visiting experimenters from the Army's Space and Missile Defense Center. The primary sensor for the Stellar Dragon Campaign, a 1.9 kHz midwave adaptive optics system, closed the adaptive optics loop for the first time on a ballistic target.

One event particularly important to the Aegis BMD program was the closed-loop tracking of a ballistic target during interception/impact with a ship-launched Standard Missile-3 interceptor/kill vehicle from the *USS Lake Erie*, the Navy's Aegis BMD test cruiser, during Flight Mission 7. The Aegis program director, Dr. Eric Hedlund, recognized AFRL's AMOS site for outstanding support and performance during the Stellar Dragon Campaign. The AFRL AMOS site is quickly becoming the centerpiece for optical data collection of Pacific missile test events due to successes such as the Stellar Dragon campaign.

Background

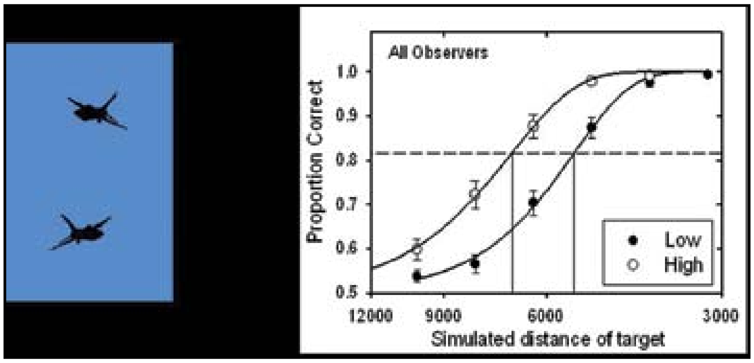
In the 1960s, the Defense Advanced Research Projects Agency constructed the Midcourse Observation Station to track intercontinental ballistic missile tests extending from Vandenberg Air Force Base, California, to the Kwajalein Atoll in the Pacific Ocean. Current AFRL AMOS site activities include missile tracking, as well as a host of other activities. For over 4 years, the Navy Aegis BMD program has used AFRL's AMOS site for a total of 10 launches from the PMRF.

Discriminating Target Aircraft Aspect Angle in an Operational Flight Simulator

Payoff

Discrimination of target aircraft aspect angle is a major component of many air-to-air flight tasks. AFRL researchers determined the distance at which observers can discriminate target aircraft aspect angle in a cathode-ray-tube-based flight simulator display system. The present data shows visual performance in such a simulator correlates with measured display resolution, but not with the number of displayed pixels (i.e., pixel count). AFRL's results indicate that display resolution should be measured in simulator applications that are dependent upon the discrimination of small displayed targets.

Accomplishment



AFRL developed an experimental procedure to assess the discrimination of target aircraft aspect angle. Laboratory experts showed participants a single aircraft simulated directly ahead of the observers at various distances and asked the subjects to determine whether the aircraft was headed toward their right or left. AFRL scientists measured display resolution using laboratory-developed techniques. For the low-resolution display, aspect angle discrimination reached an 82% accuracy level for targets at a distance of about 6,200 ft. For the high-resolution display, the equivalent discrimination range increased to about 8,000 ft. AFRL researchers determined that the commonly cited pixel count is not a valid measure of the useful spatial detail provided by a display device.

Background

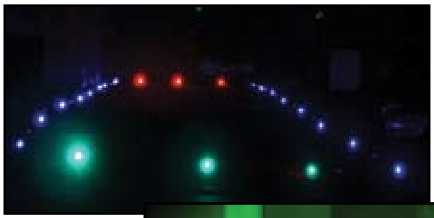
Scientists can easily ascertain and specify the number of pixels that a projection device displays. Furthermore, users intuitively believe that more pixels will provide a higher-quality image. For these reasons, they often consider pixel count as a measure of display resolution. However, increasing pixel count increases display resolution only if corresponding display bandwidth increases as well. If this does not occur, increased pixel count will result in decreased image contrast, which may actually reduce resolution. Scientists have done very few studies on the effects of display resolution on visual performance, and they have used subjective or idiosyncratic techniques for most of these studies. AFRL researchers measured display resolution using a well-documented technique that is easy to perform. They also used a direct measure of visual performance, a technique based on a task that is similar to real-world flight tasks.

AFRL Develops Dual-Mode, Visible/Covert, Portable Airfield Lighting System

Payoff

Department of Defense warfighters need a portable airfield lighting system for visible and covert operations. In the covert mode, the lights are visible only through night vision goggles (NVG), bringing a significant capability enhancement and added safety to the warfighter.

Accomplishment



A team of AFRL researchers, in conjunction with engineers from Optical Research Associates (Pasadena, California) and Cooper Crouse-Hinds (Syracuse, New York), designed, built, and demonstrated a portable airfield lighting system in less than 36 months. Based on efficient light-emitting diode (LED) technology, the system meets Federal Aviation Administration (FAA) medium-intensity airfield lighting requirements, while consuming one-third the power of conventional portable airfield lighting systems.

The system's built-in, infrared-only, NVG-visible mode enables covert operations—an essential capability for winning today's asymmetric conflicts. In addition, the portable taxiway light developed as part of this effort is currently available to the civilian market from Cooper Crouse-Hinds.

AFRL also previewed the system at the annual Team Patriot exercise to leverage the austere airfield available at Fort McCoy, Wisconsin, and the fixed concrete and asphalt runway at Volk Field Air National Guard Base, Wisconsin. AFRL engineers wanted to demonstrate this portable lighting system in two different environments. The exercise's participating units provided important feedback to the research team.

Background

For years, incandescent light bulbs have been the industry standard for both portable and fixed airfield lighting systems. Incandescent lights are less reliable than LEDs and consume significantly more power. As a result, the portable systems currently used by the Air Force (AF) cannot meet the FAA's medium-intensity lighting requirements. Furthermore, the current system does not possess a covert mode that is visible only through NVGs. Recent advances in LED technology, however, have improved LED efficiency and output/intensity, allowing them to meet the airfield lighting requirements that the AF desires for its portable systems.

AFRL Supports F-35 Joint Strike Fighter Test Program

Payoff

AFRL scientists and their commercial partners are conducting sophisticated antenna testing on the Lockheed Martin F-35 Joint Strike Fighter (JSF). Once in production, thousands of F-35s are expected to be provided to the Department of Defense, with the Air Force (AF) receiving a conventional version; the Navy receiving an aircraft carrier variation; and the Marine Corps, a short-takeoff and vertical landing model.

Accomplishment

The JSF is a stealthy, supersonic, multirole fighter designed to replace a wide range of aging fighter and strike aircraft, including the AV-8B Harrier, A-10, F-16, and F/A-18, along with the United Kingdom's Harrier GR.7 and Sea Harrier. Three variants derived from a common design will ensure the F-35 meets the performance needs of the AF, Navy, and Marine Corps, as well as allied defense forces worldwide. Lockheed Martin is collaborating with its principal partners, Northrop Grumman and BAE Systems, to develop the F-35.

AFRL's Newport Antenna Research and Measurement Facility, in Newport, New York, is a world-class antenna measurement facility that has provided multiple outdoor test ranges for over 30 years. The facility owns models of all AF tactical air assets and recently added aircraft models from other services.

Lockheed Martin contracted with AFRL in an attempt to identify problems before the aircraft enters production mode and flight testing. In the Newport facility, scientists evaluate antennas and antenna systems in a far-field, free-space-like environment; determine radiation pattern changes due to airframe effects; evaluate antenna-to-antenna system coupling; and support advanced antenna measurement technology development. Researchers can obtain more data in 8 minutes spent using the facility than they would collect in 2 hours spent flying the future F-35.

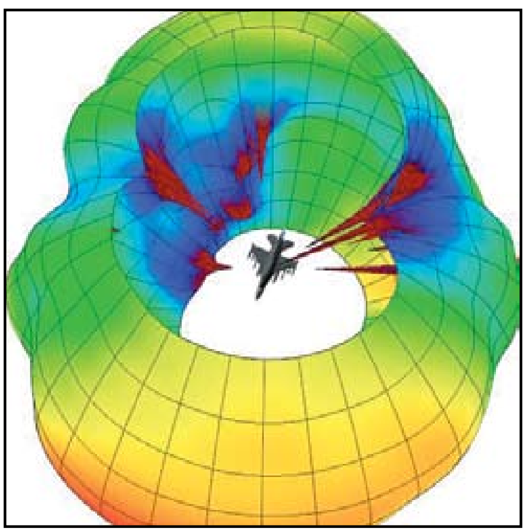
Background

Advanced Technologies, Inc., located in Newport News, Virginia, designed and built the full-scale F-35 model. The model weighs 8,500 lbs and, with its interchangeable wing and tail components, can simulate all three JSF variants. AFRL provides and manages its outdoor antenna test ranges to support the JSF test program; the laboratory also supplies personnel from its Site Operations Division fabrication shop to manufacture replicas of the F-35's external fuel tanks, weapons, and landing gear.

AFRL Releases Newest Information Visualization Application Programming Interface Programs

Payoff

AFRL released an information visualization application programming interface (API) known as JView API version 1.3, as well as the JView Audit Trail Viewer (ATV) version 1.1. Scientists developed JView to reduce the time, cost, and effort associated with the creation of computer visualization applications or the visualization portion of an application. JView provides the ability to quickly develop two- and three-dimensional (3-D) visualization applications tailored to address specific problems. Approximately 75 government, commercial, and university organizations use JView for purposes ranging from the development of operational applications to basic research.



Accomplishment

AFRL's research promotes the advancement of software design, runtime reconfigurability, and graphics and graphical interaction. The laboratory's research is directly supporting the creation of applications based upon these ideas. Implemented through JView, such applications will initially support Department of Defense customers. JView allows programmers to produce robust and flexible applications to quickly address user needs. Updates to JView include enhancements such as constructive 3-D geometry, imagery formats (military and commercial), continuous-level-of-detail algorithms, and support for uniplexed information and computing system platforms.

Background

AFRL used JView to create the ATV as a replacement for IView 2000. The laboratory initially created the ATV to support the display of air engagement simulations at the National Air Intelligence Center at Wright-Patterson Air Force Base, Ohio. The ATV allows visualization, playback, analysis, and movie generation of various recorded simulation file formats. The ATV supports the 3-D representation of the simulation entities as Wavefront .obj models, OpenFlight® .flt files, or .gif files, and newer formats as well. This confluence of input and output capabilities allows customers to use the ATV for real-world analysis and presentation. The JView API and ATV are government-owned and available free of charge to government agencies and their contractors.

Scientists Develop Ceramic-Based Body Armor for Warfighters

Payoff

AFRL scientists and engineers collaborated with industry to develop a novel metal-ceramic hybrid material for use in higher-performance, lighter-weight small arms protective inserts (SAPI) for body armor vests. In 18 months, this low-cost, high-payoff technology development program evolved from initial laboratory research into a technology system that exceeds the capabilities of most existing SAPI plates. If the technology continues to perform beyond specified requirements, AFRL scientists expect several military branches to purchase it at a cost savings of approximately $400 per armor vest, resulting in a total cost savings in the millions.

Accomplishment

AFRL teamed with Excera Materials Group, Inc., of Columbus, Ohio, in this effort. The group used the Edison Materials Technology Center Cooperative Technology Exchange program, the Navy Phase II Small Business Innovation Research program, and AFRL funding to develop a prototype SAPI strike plate that exceeds the US Army's performance standards for fielded applications. AFRL's Second Lieutenant T. J. Turner spearheaded a cost-effective, rapid effort to develop the body armor using geometric means to stop a bullet. He proposed creating a lightweight, layered composite panel with angled external tiles that would cause bullets to tumble and stop instead of piercing armor plating on tanks and aircraft. AFRL's program became an effort to develop a lighter-weight, metal-infused ceramic laminate for soldiers' battlefield flak vests.

Background

In order to stop an assault rifle bullet, armor must have properties that will crack or blunt the point of a bullet. The material must also have fiber backing that will catch bullet fragments and absorb the pressure wave generated when a bullet strikes the armor. The development of ceramic materials that retain high hardness, even in the shapes required for body armor applications, is a daunting task. All current SAPI plates are composed of press-sintered ceramic materials, which are very hard but make the strike plates heavier and more fragile than desirable.

AFRL Delivers Expendable Robot for Remote Improvised Explosive Device Neutralization

Payoff

AFRL engineers prototyped, developed, and delivered low-cost, compact, remote-controlled robots—known as BomBots—to disable and dispose of improvised explosive devices (IED). AFRL delivered the BomBot to support requests from Air Combat Command, the Marines, and Central Air Forces during various mission profiles in Haiti, Afghanistan, and Iraq. This program demonstrates AFRL's commitment to rapidly deliver cutting-edge technology solutions, exceed the capabilities of existing systems, and meet urgent and compelling warfighter needs.

Accomplishment

AFRL engineers responded to an urgent request from the joint services explosive ordnance disposal (EOD) community to develop a low-cost, remote-controlled, rapidly deployable robot for placing explosive charges on or near an IED without endangering the system operator. This compact and versatile system costs approximately $6,700, far less than current robots used for this purpose, which also have a greater logistical burden. In just 90 days, AFRL delivered the first BomBot prototypes to users in rigorous environmental conditions.

Background

When EOD personnel identify an IED, they rarely attempt to remove it by hand. Instead, they approach the IED remotely, sometimes dispatching costly ($110,000-$140,000) robots to disable or detonate the packages. In addition to their expense, many of these current systems are also large—transportable only by trailer or Humvee—and capable of moving just a few miles an hour. As a result, these robots sometimes draw unwanted attention to an incident site, where a safe standoff distance is imperative.

The BomBot is a modified remote-controlled, four-wheel-drive truck equipped with a pan-and-tilt camera and a charge dispenser. The operator regulates the robot's speed, which can reach 30-35 mph. AFRL collaborated with Nomadio, Inc., to provide the robots with secure, frequency-hopping command and control, as well as the capability to relay information to the operator from its sensing devices. EOD personnel can use the system several times daily in rigorous environmental conditions, allowing force protection and IED disposal activities to occur from a safe standoff distance. AFRL transitioned the entire program to the Navy EOD Technology Division's Indian Head Naval Ordnance Station, Maryland, where personnel are working closely with the West Virginia High-Technology Consortium to initiate production on the final version of the BomBot.

AFRL Cooperative Venture Transitions Joint Programmable Fuze

Payoff

AFRL researchers developed solutions to quality-workmanship-related issues that prevented the initial production of the joint programmable fuze in the Joint Direct Attack Munition. AFRL's successful intervention allowed the contract company, Kaman Dayron (Bloomfield, Connecticut), to produce the fuze and pass the Air Force's (AF) first-article acceptance test. As a result, Kaman Dayron now produces over 500 fuzes per month, enabling AFRL to begin delivery of this vital new fuze capability to the warfighter.

Accomplishment

AFRL worked with TechSolve (Cincinnati, Ohio) to help Kaman Dayron overcome quality-workmanship issues. Prior to AFRL's involvement, workmanship defects led to the supplier's three consecutive unsuccessful attempts to pass AF standards. AFRL transitioned lean manufacturing improvements, including value stream mapping, creation and implementation of visual work instructions (VWI), and implementation of a just-in-time Kanban supply system for the vendor.

To produce the fuze, the current state value stream mapping identified the critical path of assemblies based on lead time. Researchers developed time comparisons and staffing calculations for operator cycle time, machine cycle time, setup time, quality, and uptime. They developed a guided approach for the level load schedule for final assembly and used a Kanban system to supply subassemblies. These manufacturing improvements enabled Kaman Dayron to meet and exceed aggressive production rates to satisfy AF warfighter requirements for the fuze.

Background

Prior to implementing VWI, operators used engineering documentation to build assemblies. This documentation consisted of written instructions and a few black-and-white drawings. Documentation was often confusing and rarely showed the component orientation or the installation process. TechSolve worked with the operators and manufacturing engineers to establish the best practices and then documented these practices with photos and written descriptions. Kaman Dayron developed a solder map checkoff sheet to illustrate each solder joint. The use of VWI and solder map sheets led to the elimination of workmanship defects.

The team employed a Kanban system to trigger production subassemblies, level the demand, balance the production cells, and establish a steady supply of raw material. They used a two-reel Kanban system to supply the surface mount technology machine.

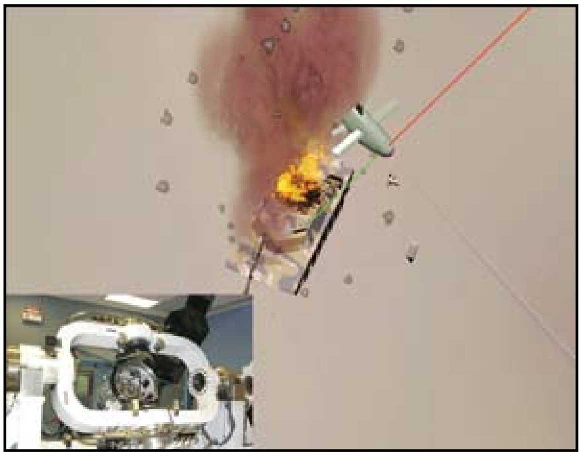
KHILS Facility Provides a Virtual Proving Ground for the P-LOCAAS

Payoff

AFRL's Kinetic Kill Vehicle Hardware-in-the-Loop Simulator (KHILS) facility is an invaluable tool for supporting successful flight tests. Scientists use the facility to evaluate advanced-capability weapons with laser radar seekers and thus demonstrate the potential of autonomous munitions such as the Powered Low-Cost Autonomous Attack System (P-LOCAAS). The P-LOCAAS tests conducted at the KHILS facility resulted in a highly successful ground test program, minimizing the risk of potential failures in a high-visibility flight test activity.

Accomplishment

Over the past 5 years, AFRL's KHILS facility provided preflight risk reduction support for six free-flight tests associated with P-LOCAAS development. KHILS and Lockheed Martin engineers worked together to debug and fine-tune P-LOCAAS guidance and target recognition systems prior to flight. The successful results of all six flight demonstrations were due to KHILS testing, proving the value of hardware-in-the-loop (HIL) simulation, the benefit of AFRL/defense contractor collaboration, and the effectiveness of the P-LOCAAS technology.



Background

The KHILS facility provides a proving ground for some of the world's most advanced weapon systems. Scientists use KHILS equipment to integrate weapon guidance hardware components and embedded seeker software, which provides smart weapons their intelligence, to simulate a weapon and evaluate integrated weapon performance.

In the KHILS test environment, simulators replicate real-world phenomena using sensor responses that occur at real-world rates. In the real world, the seeker collects an image in the battlefield, slewing in azimuth and elevation to collect data. In the simulated world, the seeker's orientation must be calculated with respect to the position of the airframe and the battlefield below. Target signature computer models calculate the measured laser returns from the simulated target and background. These calculations must occur without introducing delays that could destabilize finely tuned guidance and control systems or impact logic that identifies precisely when to fire the warhead.

To accomplish these tasks, AFRL's test environment developers worked closely with Lockheed Martin (Dallas, Texas) weapons developers. Scientists designed interface hooks in the weapon system with HIL testing in mind. The team established close working relationships to communicate the nuances of the P-LOCAAS design, implement simulation models, and expedite the transition of software and hardware between Lockheed Martin and the US government.

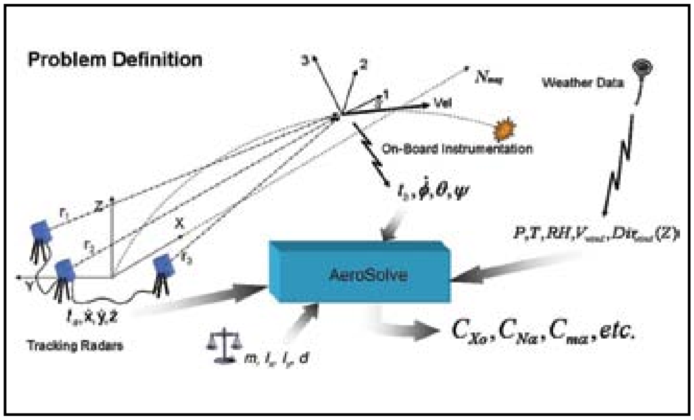
AFRL Engineer Develops New Aerodynamic Analysis Capability

Payoff

Dr. Gregg Abate, an AFRL exchange engineer at the Ernst Mach Institute (Freiburg, Germany), developed a new method to determine aeroballistic parameters from projectile flight data. His procedural solution allows users to specify aerodynamic parameters for inclusion in—or exclusion from—the modeling procedure. Additionally, users can specify an earth-fixed or body-fixed dynamic model and also filter experimental data by Mach number, angle of attack, and/or signal-to-noise ratio. The new method allows users to analyze multiple shots; therefore, data density increases and resulting statistical averages more accurately represent the data obtained from repeated tests with identical nominal firing conditions. Dr. Abate's method also includes an automatic analysis module, allowing users to rapidly process—and plot—the experimental data.

Accomplishment

In Dr. Abate's new method, the instantaneous position, motion state, physical properties, and environmental conditions determine the aeroballistic parameters. The Windows®-based graphical user interface of AeroSolve analysis software makes this possible. Users employ the extracted aeroballistic parameters for flight prediction and simulation. In application, the measured flight data is segmented into user-defined Mach number ranges where the aeroballistic parameters vary slowly. This avoids the problem of extreme nonlinearity of the aeroballistic parameters at Mach 1, as well as problems with trajectory matching using extremely long trajectories.



Scientists successfully validated the AeroSolve package through the use of synthetic data generated by a six-degree-of-freedom trajectory simulation. AeroSolve effectively determined the aeroballistic coefficients used in the simulation. Additionally, modest levels of Gaussian error corrupted the synthetic data. AeroSolve was also able to determine the aeroballistic parameters from the corrupt data, albeit with greater levels of uncertainty.

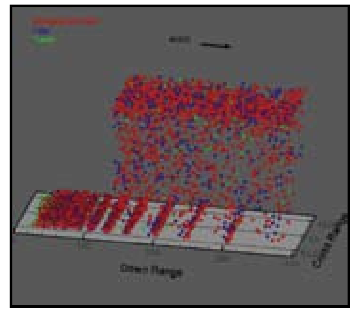
Background

Dr. Abate was assigned to the Fraunhofer Institute for High-Speed Dynamics, also known as the Ernst Mach Institute. In that exchange assignment, he assisted in the development of free-flight test facility improvements, numerical modeling of munitions, and free-flight data analysis techniques. He participated in the AFRL-managed Engineer and Scientist Exchange program, a Department of Defense effort promoting international cooperation in military research, development, and acquisition through the exchange of defense scientists and engineers.

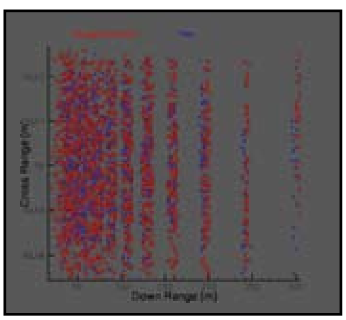
Scientists perform traditional aeroballistic data analysis via free-flight spark ranges. In these facilities, they measure the position and attitude of the projectile versus its time. They derive the resultant aeroballistic parameters by matching integrated equations of motion to the measured data. Recent advances in radar technology—onboard sensors, in particular—made it possible to directly measure data suitable for the identification of the free-flight projectile dynamics, such as linear and angular accelerations, velocities, and/or positions. However, the data analysis method that scientists use to derive the aeroballistic parameters still relies on modeling the aerodynamic coefficients and stability derivatives such that the integrated equations of motion match an observed trajectory.

Particle Tracking Through Advanced Multiphase Flow Simulation

Payoff



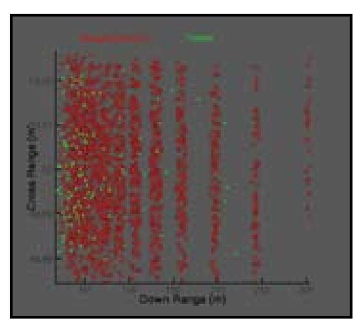
AFRL is dedicated to defeating biological weapons such as certain spore-forming bacteria. Scientists desire a computational tool to accurately track tiny particles through a highly turbulent mix of air and explosive gases and to precisely determine the particles' downwind settling locations. AFRL sponsored the Georgia Institute of Technology to conduct a multiphase research effort to develop Three-Dimensional Large-Eddy Simulation (LES3D), a computer program that captures subtle, turbulent motions in the flow field. LES3D can accurately simulate particle motion through complex flow fields to support Air Force (AF) weapons programs.



Accomplishment

AFRL sponsored research in multiphase computational fluid dynamics (CFD) to predict airborne particle motion. This area of research is relatively new and involves several disciplines, including gas phase chemistry; particle transport; turbulence; and the science associated with coupling gas, liquid, and solid phases within classical dynamics. Turbulence is a common component of multiphase physics, and the research shows that CFD algorithms must properly address it to track small particles accurately. Essentially, the particle phase (or droplet phase, for liquids) must be correctly coupled within governing equations for viscous flow fields to correctly simulate the interaction between particles and the surrounding gas.

Background



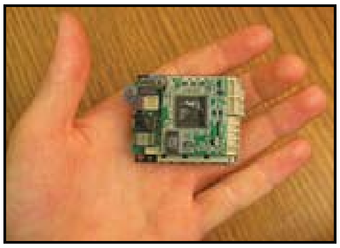
Since the late 1990s, the AF has become increasingly interested in countering the threat posed by weapons of mass destruction, including spore-forming bacteria that can be stored and released in powdered form. If these spores enter the atmosphere as the result of a detonation, the resulting hot gases can loft them higher into the air, at which heights the wind may carry them toward population centers. In fact, the particles' minute size and weight allow prevailing winds to carry them great distances; moreover, atmospheric turbulence may cause these particles to follow irregular paths and ultimately settle in unexpected locations. Thus, the AF has great interest in effective simulation of the physics associated with particle transport.

Autopilot Development for Micro Air Vehicles

Payoff

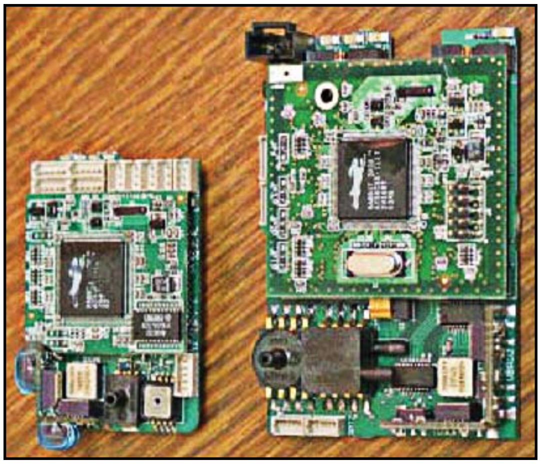
AFRL is combining warfighter requirements and the latest avionics technologies to develop autopilots that enable effective micro air vehicle (MAV) systems. The development of smaller autopilots will enable even smaller and less expensive unmanned air vehicles (UAV).

Accomplishment



During 2003, AFRL contracted Procerus™ Technologies to develop the Kestrel version 1.45 autopilot. This unit included features to enable autonomous flight, a data link interface, three servo position commands, and a Global Positioning System (GPS) input interface. It weighed 40 g and test-flew in UAVs weighing under 1 lb. In 2004, Procerus created the Kestrel 2.0 autopilot, a more capable autopilot weighing just 16.7 g.

The Kestrel 2.0 autopilot includes the sensors and interfaces required for a functional and easy-to-use UAV. The unit's three accelerometers, three temperature-compensated rate gyros, GPS interface, pressure transducers for airspeed and altitude, and four servo outputs enable autonomous flight with GPS navigation. A modem interface allows users to upload new waypoints and download sensor data. Engineers made provisions for an integrated payload system by including payload communication and control and supplying electrical power at 3.3 V and 5 V.



Background

MAVs are the size and shape of small, radio-controlled hobby aircraft. With the miniaturization of avionics and sensors, they are becoming valuable battlefield assets. Autopilot hardware and software benefited from a spiral development approach. Engineers can easily update both hardware and software to meet future needs and requirements. While the Spiral 1 (Kestrel 1.45) development effort satisfied initial control conditions, engineers rapidly implemented lessons learned in Spiral 2 (Kestrel 2.0). As requirements continue to evolve with warfighter input, flight test results, and supplier data, engineers will continue to incorporate new technology in future spiral development cycles in support of those needs.

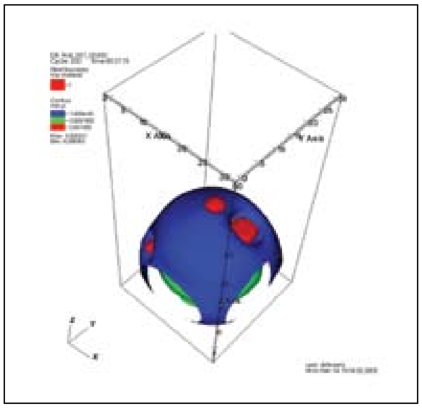
Small, capable autopilots enable the development of MAVs that satisfy multiple missions. Because the Kestrel 2.0 autopilot enables autonomous navigation, provides payload support, and allows data link communications in a remarkably small package, it is uniquely suited for such broadscale MAV development. AFRL will continue to add autopilot capability, while minimizing size and cost to support tomorrow's warfighter.

AFRL Develops Low-Collateral-Damage Weapon Design

Payoff

AFRL is currently utilizing high-fidelity physics-based simulations to aid in the design and testing of low-collateral-damage (LCD) munitions. LCD munitions will benefit the warfighter during urban conflicts where standard munitions would inflict unacceptable collateral damage levels.

Accomplishment



AFRL partnered with Lawrence Livermore National Laboratory (LLNL) to employ a physics-based code in the design and evaluation of the munitions, which is based on a dense inert metal explosive (DIME) technology. Scientists used the base hydrocode to perform many simulations of interest to LLNL and AFRL. The code requires a DIME-specific multiphase flow capability to accurately simulate the DIME-type munitions. The laboratory is continually validating this new capability as the program progresses.

AFRL is utilizing this new capability to assist in the design and validation of LCD weapon concepts. The unique simulations provide the testing community with valuable insight in the areas of weapon detonation physics and blast wave interaction with structural targets involved in the test. The code's physical fidelity provides valuable data that allows the researchers to accurately quantify the differences between standard and LCD munitions. This capability allows the team to make timely, informed concept decisions and is more cost-effective than trial-and-error testing.

Background

This collaborative effort is taking great strides to advance the knowledge of LCD munitions and demonstrates the value of high-fidelity simulations in weapon development programs. The team's research impacts the weapon design from the explosive material's formulation to the weapons case design and actual setup of the physical proof-of-concept test.

AFRL Conducts Successful Microelectromechanical Systems Inertial Measurement Units Flight Tests

Payoff

AFRL conducted successful flight tests of microelectromechanical systems (MEMS) inertial measurement units (IMU) for data collection and performance validation using the Joint Direct Attack Munition (JDAM). The flights demonstrated the MEMS IMU capability to provide stable navigation performance and accurate weapon guidance, particularly with Global Positioning System (GPS) updates. This data will aid the Air Force (AF) effort to further develop MEMS IMU technology to meet the future needs of air-launched munitions, including JDAM.

Accomplishment

AFRL and Boeing integrated the Honeywell HG1900 Block-B MEMS IMU into JDAM tailkits and conducted a captive-carry and guided-weapon release flight under a Cooperative Research and Development Agreement. AFRL provided MEMS IMUs to Boeing to integrate into JDAM tailkits. AFRL and Boeing performed the planning and preparation associated with the JDAM flight tests.

The team's flight tests demonstrated navigation with and without GPS updates to the IMU inertial data. Guidance performance was stable and showed great improvement over previous versions of the MEMS IMU. Scientists collected significant data to conduct extensive analysis of IMU characteristics and validation of performance models. Boeing and Honeywell will use the flight tests' performance characteristics to determine improvements for the next versions of the HG1900 to meet requirements of JDAM and other munitions. These flight test results will allow the AF to optimize future planning and development of MEMS-based IMUs.

Background

The government has researched IMU application for munition navigation and guidance for many years. MEMS IMUs can overcome the limitations of size, weight, and cost of current spinning mass, fiber-optic, and ring laser gyro IMUs. The performance of MEMS IMU technology is approaching the tactical grade requirements of many current and future miniature munition concepts.

Boeing's JDAM GBU-31, currently in production, is a guidance tailkit that provides an all-weather, autonomous, high-accuracy bombing capability to existing "dumb" unitary bombs. Plans for product improvements and technology insertions are present throughout the JDAM delivery schedule.

New Rechargeable Battery Packs and Recharger Provide Continuous Operating Capabilities to the Warfighter

Payoff

AFRL designed and built rechargeable, state-of-the-art lithium battery packs and a universal recharger for Air Force Special Operations Command (AFSOC) small unmanned air vehicles (UAV) in less than 4 months. These packs reduce the annual operating cost of batteries for AFSOC's Pointer and Raven UAVs by nearly two orders of magnitude (~1/70 of the current cost). These new packs will last for hundreds of cycles, and their associated rechargers will last for thousands of cycles, dramatically increasing system field life. These rechargeable packs provide the Air Force a tremendous savings in operational cost and logistics, along with greater flexibility to recharge the packs in remote locations worldwide.

Accomplishment

In response to battery pack issues that surfaced in Operations ENDURING FREEDOM and IRAQI FREEDOM, AFRL teamed with Colorado Power Systems to refine initial rechargeable battery development for AFSOC's Pointer UAV. The rechargeable battery packs, in conjunction with the recharging unit, provide a substantial increase in operational utility and solve major logistical challenges for small UAV operation in harsh locations worldwide. The packs have passed flight testing, and multiple vendors are commercially producing them. The associated battery pack recharger has also passed rigorous field testing and provides a first-ever, worldwide recharging capability.

The initial development achieved a breakthrough in field deployment and the Pointer UAV's resupply problems. This development increased the number of systems that the rechargeable battery packs can support. The battery pack technology commercially benefits the Pointer and Raven UAVs, and it now extends to other, non-UAV equipment as well. The system of two battery packs and one recharger will provide continuous operating capability to a warfighter's system.

Background

The problem related to battery packs became a critical issue as the war in Iraq began. The nonrechargeable lithium-sulfur dioxide battery packs were present in a wide variety of military equipment, mostly in the form of the BA-5590 battery pack. When production capabilities peaked, critical shortages occurred. The response to this potential problem was to develop an alternative source for the Pointer UAV.

The latest development increased the battery packs' energy by 10%, which translates to a nearly 20% increase in the Pointer's on-station time. Commercial technology is continually improving the energy storage capability of the battery cells, while maintaining the original battery cell size and shape. As the commercial sector improves the technology, the improved cells will directly increase warfighting capabilities, with essentially no additional cost to the government.

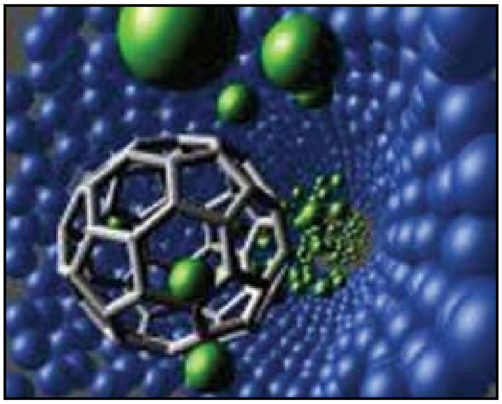
AFRL Successfully Produces Explosive Charges With Nanoscale Aluminum Powder

Payoff

Scientists successfully incorporated nanoscale aluminum powder into a series of experimental explosives developed at AFRL's High Explosives Research and Development (HERD) facility. Production issues have plagued nanoparticle-containing formulations. Formulation difficulties arise because powders with large surface areas require too much fluid for coating. Therefore, only a small fraction of nanoscale aluminum powder in a formulation causes a cast-cure or melt-cast explosive to become so viscous during mixing that researchers cannot process and load it in the traditional manner. The HERD researchers overcame this issue and produced research-quality pressed charges using molding powders.

Accomplishment

AFRL researchers at the HERD facility achieved a high percentage of theoretical maximum density with a very low variation in density of all the pressed pellets, making an ideal item for fundamental testing. Researchers will utilize these pellets to test the hypothesis that nanoscale particles will accelerate aluminum's energy release rate to the timescale of an explosive detonation. AFRL completed a contracted effort to develop additional nanoformulations utilizing the laboratory-developed technique. Scientists will conduct fundamental detonics testing in the near future.



Background

Researchers are performing a systematic, phenomenological study to definitively establish the extent to which nanoparticle size can accelerate the combustion rate. In order to conclusively determine the extent of this effect, AFRL is conducting highly repeatable experiments, necessitating the availability of highly consistent, precision charges. Both metal acceleration and blast effects are desirable in an explosive. The current generation of explosives uses aluminum that reacts relatively slowly and manifests itself as blast energy. Recent modeling efforts have shown that nanoaluminum powders have the potential to react within the reaction zone of the detonation wave, thus providing useful energy for accelerating metal.

The performance of nanoenergetics has the potential to improve due to a more rapid and complete combustion of the aluminum powder in the nanoformulation (compared to standard formulations using micron-sized aluminum). Scientists expect an increase over micron rates and/or performance due to the drastic increase in the nanoparticles' surface area.

AFRL Demonstrates Weapon Lock-On After Launch Capability

Payoff

AFRL gained significant knowledge and experience during the Maverick Lock-On After Launch (LOAL™) Utility Evaluation (UE) with respect to weapons initiatives including weapons-compatible data links, network-smart weapons, and plug-and-play integration of weapons platforms. AFRL engineers can directly apply this knowledge to future Air Force development activities.

Accomplishment

AFRL successfully completed the Maverick LOAL UE program. The Air Combat Command's Requirements Directorate sponsored the effort, which demonstrated the LOAL concept's capability in a series of captive flight tests.

Raytheon Missile Systems (Tucson, Arizona) evolved the LOAL concept following the success of Affordable Moving Surface Target Engagement flight tests held in 2001. The 46th Test Wing's 40th Flight Test Squadron (Eglin Air Force Base, Florida) conducted the flight missions and successfully evaluated the functional capability and utility of the newest Maverick missile concept. This new missile concept provides man-in-the-loop endgame control for precise attacks at greater standoff ranges against targets.

Background

The Maverick is a precision, air-to-ground missile that pilots can use against small, hard targets. The missile has launch-and-leave capability, which enables the pilot to lock onto the target, launch the Maverick, and then take evasive action.

The LOAL Maverick provides man-in-the-loop endgame control for precise attacks against preplanned targets, through or under current cloud conditions. LOAL Maverick missile launches are possible at significant standoff ranges and altitudes and thus do not require a pilot's line of sight to the target. They are also fully compliant with today's employment rules of engagement. Additionally, all of today's Maverick-capable aircraft can employ LOAL Maverick missiles without modifications to operational flight programs or the aircraft itself.

AFRL Battery Research Program Benefits Navy SEAL Program

Payoff

Since its initiation in 1998, the AFRL lithium-ion battery technology program has led to power solutions for systems such as the B-2 Bomber, the Mars rover, and new commercial products. Recently, the Navy adopted the technology to power its advanced combat support equipment.

Accomplishment

The AFRL program's most recent propagation was the US Navy's selection of Lithion, Inc./Yardney Technical Products for its Phase II Advanced Sea, Air, Land (SEAL) Delivery System. The Advanced SEAL Delivery System (ASDS) is a submersible combat vehicle that the Navy SEAL team will use to transport team members and combat equipment to and from shore, enabling a variety of special operations missions. Lithion, Inc., explicitly credits AFRL's lithium-ion research for its opportunity to experience success in this technology area, and the company also acknowledges the Air Force as the most important partner in advancing lithium-ion technology as the power source for many new applications.

Background

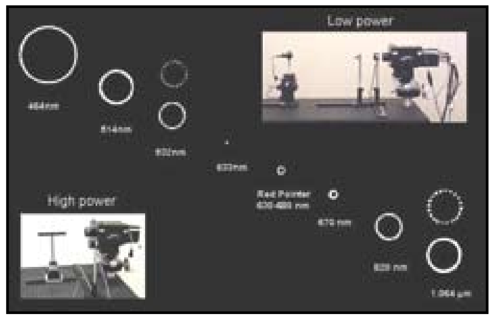
AFRL and its industry partners have been the focal point for this technology. Scientists have developed lithium-ion technologies as a result of AFRL programs. Consequently, this technology has satisfied the power needs for the National Aeronautics and Space Administration's Mars exploration rovers, the B-2 Bomber, several satellite applications, and the Navy ASDS application. Further opportunities exist to expand lithium-ion technology into areas related to unmanned air vehicles, battlefield air operations, directed energy weapons, and smarter electronic designs.

AFRL Technology Provides Instantaneous Laser Threat Warning Information

Payoff

A team of AFRL scientists invented, developed, and demonstrated a technique to detect, classify, and locate lasers in real time virtually anywhere in a theater of operation. The team demonstrated that operating its Spectral-Temporal Sensor (STS) can detect, classify, and locate continuous wave (CW) and pulsed lasers over the spectral region from 0.49 to 1.06 micrometers (μm). Successful implementation of this STS technology will provide warfighters with nearly instantaneous threat warning information. STS, combined with the AFRL team's related Chromotomographic Hyperspectral Imaging Sensor approach, could enable warfighters to stare at an entire battlespace and acquire detailed spectral evolution of energetic battlefield events, such as those involving bombs and missiles, or pulsed and CW lasers, in near real time.

Accomplishment



AFRL's Sensors team at Hanscom Air Force Base (AFB), Massachusetts, used a visible/near-infrared STS instrument, invented in-house, to demonstrate that detecting, identifying, and locating lasers is very promising. First, they used reflected laser energy from simple laser pointers to determine if their predictions would work. Next, they designed an experiment to determine the sensitivity of the STS by collecting data on CW lasers ranging from 464 nm to 1.064 μm and pulsed lasers at 532 nm and 1.064 μm.

Data collection occurred at the Enhanced Recognition and Sensing Laser Radar field test held at Eglin AFB, Florida. During this test, the team collected rapid temporal-spectral data on solid-state, nanosecond-pulsed lasers at 532 nm. They then developed and implemented algorithms to automatically determine the wavelength of the laser and its position on the focal plane array. A final laboratory experiment, held jointly with AFRL engineers from Wright-Patterson AFB, Ohio, provided an opportunity to collect laser and clutter data simultaneously. Their outstanding efforts, resulted in the demonstration of the first-ever capability for agile real-time (less than 0.5 sec) pulsed and CW laser threat warning/identification.

Background

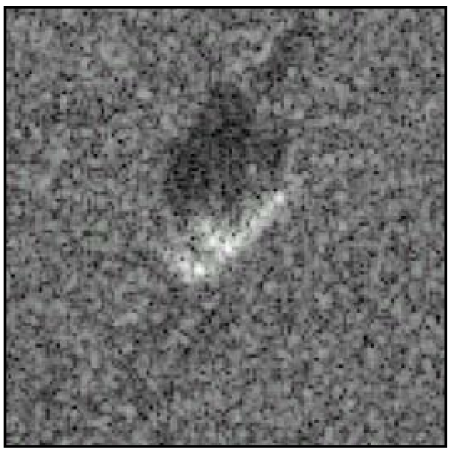
Current spectral sensors take several seconds to search large areas and perform target updates, precluding them from accurately assessing transient battlefield phenomena, such as pulsed lasers, that may last for nanoseconds. Prior STS research demonstrated both high optical throughput and staring mode operation that in conjunction with the use of suitable optics, could continuously overview the whole theater throughout the measurement.

STS data will provide nearly instantaneous measurement of the spectrum photon source as well as precise, subpixel location of the source. The STS design can be readily adapted for detecting and classifying lasers at mid- and far-infrared, as well as visible, wavelengths.

AFRL Researcher Awarded Patent for Trailblazing Radar Image Processing

Payoff

AFRL earned a patent titled "Self-Optimizing Edge Detection in Blurred, High-Noise Images." The patent identifies a self-optimizing general edge detection method that performs well in both noisy and blurred images. The technique is also suitable for use in imagery where traditional techniques begin to fail. Consequently, the Air Force (AF) will gain the ability to improve computer-aided image analysis, speeding up intelligence gathering while enhancing reliability. The AF uses several sensor systems for battlespace awareness that rely on edge detection in the core processing algorithms. This invention could enhance those systems' performance, thereby improving the accuracy of the data that warfighters use for critical decision making.

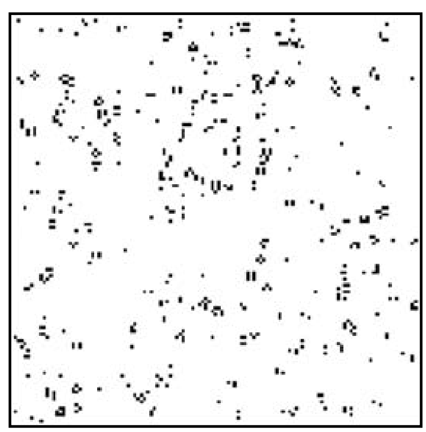


Accomplishment

AFRL performed in-house studies to explore the long-standing problem of poor automatic target recognition algorithm performance in low-quality synthetic aperture radar (SAR) images—a challenge similar to that of image processing for over-sampled optical images. The solution can also extend to other image formation methods, such as infrared and hyperspectral. Additionally, the newly patented process can handle image blurring at a level for which no other published algorithm can currently function. The new technology has the potential to improve the performance of any system that uses machine vision, such as automatic target recognition systems.

Background

Traditional edge detection methods generally require sufficiently high signal-to-noise ratios and fine image clarity to ensure the transition from one region to another does not significantly exceed 1 pixel in width. Such assumed criteria prevent conventional methods from performing successfully in blurred, noisy images. Edge detection methods adapted to noisy images still appear to carry the assumption that the noise is superimposed on the image, with edges no wider than a single pixel. Relaxing this assumption produces remarkable results observable even in relatively coarse-resolution SAR images.



In certain images, SAR acts as a magnifier and often creates an over sampled image that has no abrupt edges. The new method's algorithm enables the image to be submitted to a series of edge detection processes, using kernels tailed to border regions of increasing width until the natural edge width is found. Thus for blurred images, these successive iterations yield progressively improving results until reaching the natural edge width for the particular image.

AFRL Demonstrates Targets Under Trees Program

Payoff

The Department of Defense needs a real-time capability to find, locate, and identify targets employing concealment with camouflage and foliage. AFRL's Targets Under Trees (TUT) program rapidly gathers and correlates target information from a wide variety of sensor devices and radars and then provides the operator with clarification regarding the precise target seen—whether it is civilian (e.g., a school bus) or military (e.g., a tank).

TUT also helps determine if the target was previously identified or whether it is new to the battlefield. Most importantly, the system enables operators to detect enemy threats in concealment under trees. By automating and simplifying a process that usually requires manual examination of disparate data sources, TUT cuts the decision timeline from days to hours.

Accomplishment

AFRL first tested TUT during Sensor Week and again during the Combined Joint Task Force Exercise (CJTFEX) using Foliage Penetration (FOPEN) radar aboard an Army aircraft to detect and locate targets.

For the initial TUT test, AFRL engineers prioritized the detections and used route planning software to task a Predator surrogate aboard another aircraft. The Predator surrogate imaged the potential target locations using its electro-optic/infrared cameras and reported the results. AFRL conducted this entire process in real time using data links on both the FOPEN aircraft and the Predator surrogate aircraft.

The second test, performed as part of CJTFEX activities, further improved FOPEN/Predator real-time operations. The test demonstrated the FOPEN radar technology in an operational readiness exercise. It also gathered data from other intelligence, surveillance, and reconnaissance systems for use in analyzing fusion system performance upon completion of the exercise.

The TUT test held during the CJTFEX was more difficult due to the inclusion of three major elements: target density, time-critical target (TCT) movement, and civilian vehicles. Both test efforts were nonetheless extremely successful, demonstrating critical elements of the TCT kill chain (i.e., find, fix, track, target, engage, and assess) for targets in hiding.

Background

AFRL is managing TUT system development activities. Chartered to develop a capability for performing the find, fix, and engage aspects of the kill chain process on targets concealed by camouflage and foliage, the TUT program will enable target quality location, target identification, and kinematics.

The TUT concept is to find and identify concealed mobile ground vehicles using multisensor fusion and very-high-frequency synthetic aperture radar employing change detection techniques. TUT identifies targets by associating detections with fused intelligence information products. The TUT program will exploit existing technologies to facilitate early demonstrations and potential transitions to operational units. It will also enhance existing and maturing technologies and provide a roadmap of continued spiral development over the life of the program.

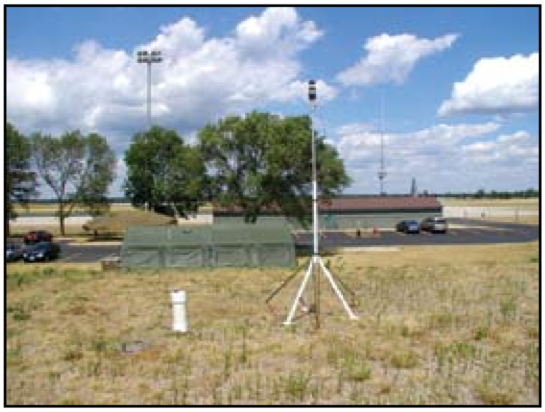
AFRL Demonstrates Cognitive Sensor Network at Team Patriot 2005 Exercise

Payoff

An AFRL team recently demonstrated and field-tested an ad hoc tactical sensor network at the National Guard's Team Patriot 2005 exercise. The Cognitive Network for Atmospheric Sensing's (CNAS) future development will enable users to obtain weather information from operational areas that are not collocated with the Air Operations Center.

Accomplishment

The demonstrated sensor network consists of many tactical weather sensor nodes. A tactical weather sensor includes a computer, an atmospheric sensor, a Global Positioning System receiver, a wireless transmitter/receiver, and a battery. The total weight of a typical tactical weather sensor node is approximately 20 lbs, which permits personnel to deploy the device.



AFRL team members demonstrated CNAS' improved capabilities during field experiments that included maximum range determination, ad hoc sensor node weather monitoring from multiple geographical locations, and operation of 3 nodes for 2 days. They also demonstrated that the network transferred weather data between nodes, performed on-node data processing, and used embedded queries to alert users of exceeded threshold values.

Background

Joint tactical operations require highly accurate, localized environmental information for applications such as all-weather landings and precision airdrops. To obtain this accuracy level, the number of observation sites must dramatically increase. This can be difficult since some observation sites are in forward operational or enemy locations.

AFRL engineers developed a sensor network that provides users with the direct availability of high-resolution and high-accuracy weather observations in the area of interest. The solution leverages Defense Advanced Research Projects Agency-developed hardware and commercial routing software and uses laboratory-developed software for the management, processing, and display of sensor observations.

Beryllium-Aluminum Alloy Components Fly on Air Force and NASA Spacecraft

Payoff

AFRL scientists, working with commercial industry, developed, tested, and transitioned beryllium (Be)-aluminum (Al) alloys to produce components for Air Force (AF) and National Aeronautics and Space Administration (NASA) spacecraft launched in early 2005. Be-Al research has increased the technology base for space vehicle design and development using cost-effective manufacturing capabilities derived from highly detailed, collaborative design processes. Stronger and lighter than the conventional materials used for building spacecraft components, Be-Al alloys have lowered the cost of placing spacecraft into orbit.

Accomplishment

The AF's in-flight Experimental Spacecraft System's (XSS-11) polar-orbiting satellite is utilizing four Be-Al alloy components, and one of three miniature spacecraft deployed for NASA's Space Technology 5 (ST5) program is utilizing a fifth component. The XSS-11 is designed to inspect other US orbital objects, such as spent boosters and dead satellites, whereas the ST5 program is designed to test innovative concepts and technologies in the harsh environment of space. Scientists created the alloys under AFRL's Metals Affordability Initiative (MAI), and they have identified additional applications as well.

Background

Scientists have successfully used Be-Al alloys in many high-performance applications, such as gas turbine engines, racing cars, space launch vehicles, and satellite structures, due to their unique combination of low density and high stiffness. The successful development of the Be-Al components for the XSS-11 and ST5 programs expanded the use of Be-Al in both primary and secondary structural applications.

The alloys investigated under the MAI covered a Be content weight range of 35%-65%. Researchers focused on materials with a lower Be content in order to manage costs. They were successful in joining subassemblies to produce complex structures and also made important strides both in materials development and component selection and design and in Be-Al component fabrication and testing. In addition, the AFRL effort succeeded in formulating and demonstrating the value of detailed collaborative design processes and the feasibility of making near-net-shape and net-shape parts.

The AF XSS-11's mission is to demonstrate the ability to autonomously plan and complete rendezvous operations with approved objects orbiting near the satellite's orbit. During the 12- to 18-month space mission, the satellite will rendezvous with 6-8 US-owned objects—inactive or dead research satellites or spent rocket stages—in its orbit.

The ST5 program objective is to demonstrate and flight-qualify several innovative technologies and concepts for application to future space missions. ST5 is part of NASA's New Millennium program. During flight validation of its technologies, ST5 may measure the effect of solar activity on the earth's magnetosphere, the uppermost atmosphere surrounding the planet.

AFRL Establishes Legacy of Successful Technology Transitions

Payoff

AFRL is responsible for the development and transition of technologies that enable advanced systems to be fielded while assuring peak performance and reducing life-cycle costs. During the past 2 years, AFRL added several significant accomplishments to its long list of successful technology development programs and the transition of resulting technologies to the operational US Air Force (USAF) and practical commercial applications.

Accomplishment

One recent success involves a joint National Aeronautics and Space Administration (NASA) and USAF program to transition the lithium-ion battery technology that powered NASA's Mars rover. The B-2 Bomber also uses the lithium-ion technology as its primary source of battery power, and the Navy is adopting it as the power source for an advanced SEAL (sea, air, and land) delivery system. The successful development of fluorene polyester capacitors reduces the weight and cost of these battery power systems. Likewise, silicon carbide Schottky diodes increase the power system efficiency of both commercial and military electronic components. Additionally, scientists successfully completed demonstration programs that involved technologies such as turbine engine low-spool-mounted generators to enable power sensor systems upgrades, as well as advanced high-power cooling technology demonstrations required for high-power microwave anode.

Background

AFRL researches, develops, and transitions superior air and space power systems to the warfighter. AFRL has established a track record of successful development and transition of power technologies for both current and future USAF weapons systems.

AFRL's XSS-11 Successfully Launches

Payoff

AFRL developed the $80 million Experimental Spacecraft System (XSS-11), a new class of low-cost satellites that weigh roughly 100 kg. The XSS-11 will demonstrate technologies that will help to reduce the costs of operating, launching, and building a satellite. The XSS-11 will also help to pave the way for future space servicing, diagnostics, maintenance, and space support missions.

Accomplishment

Scientists launched the XSS-11 into orbit on the Minotaur small launch vehicle from Vandenberg Air Force Base, California. The orbit had a 98.8° inclination, almost perfectly circular, at an altitude of about 850 km. The XSS-11 successfully completed its launch and early orbit operations as scientists carefully turned on, thoroughly tested, and fully characterized each subsystem. The XSS-11 has a 9-ft wingspan and, at approximately the size of a dishwasher, is much smaller than a typical satellite.

Background

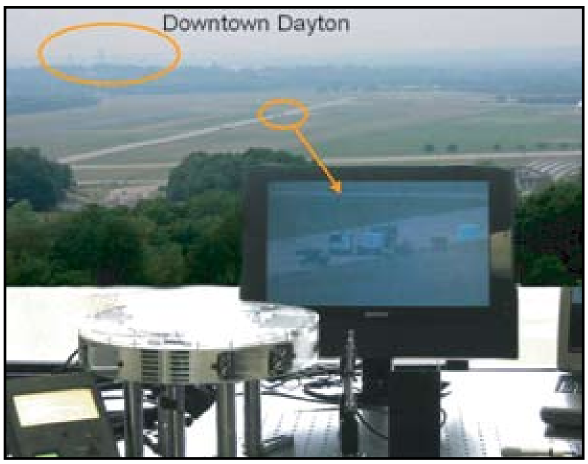
The XSS-11 will demonstrate the ability to autonomously plan and complete rendezvous operations with approved space objects near the satellite's orbit. During its 12- to 18-month space mission, the satellite will rendezvous with 6-8 approved, US-owned objects—inactive or dead research satellites or spent rocket stages—in its orbit.

A sophisticated onboard planner enables the XSS-11 to encounter these objects. The onboard planner is a radiation-hardened Power PC 750 processor, which provides the XSS-11 the ability to autonomously plan operations. The planner will consider a series of objectives (e.g., going to an expended rocket body) and constraints (e.g., waiting for approval from the ground) and build a plan to accomplish the objectives with respect to those constraints.

AFRL Develops Advanced Tactical Directed Energy System

Payoff

AFRL developed the Advanced Tactical Directed Energy System (ATADS). This technology demonstrator validates a robust laser countermeasure (LCM) effective against current reticle scanning missile threats, as well as more advanced threats. The LCM uses multiband, high-power midinfrared semiconductor lasers to provide a robust, expanded counterthreat capability at significantly lower costs and greatly increased reliability. The small footprint and enhanced effectiveness of these semiconductor-based units will allow ready integration on a wide range of Air Force (AF) platforms and provide superior protection. The ATADS represents an upgrade for the Large Aircraft Infrared Countermeasures (LAIRCM) System Squadron. ATADS provides an increased counterthreat capability and significantly reduces costs in the LAIRCM Phase III system, saving more than $300,000 per set.



Accomplishment

AFRL demonstrated and evaluated the ATADS laser component at a laser infrared development range. Scientists pointed the laser source 2 km downrange at a trailer containing active missile seeker heads and statically tested the laser against five different foreign and domestic threats. The laser component was able to interrogate, identify, and jam several threats, and the ATADS unit defeated threats. Another significant result was the first-time demonstration of a closed-loop infrared countermeasure using a semiconductor laser. The laser jammed the threats more rapidly than expected, which increases the number of threats that the AF can counter. The test results generated interest from the LAIRCM System Squadron, the Army and Navy research labs, and several Department of Defense contractors.

Background

Infrared countermeasure systems that are compact, efficient, and low cost, and offer increased counterthreat capability will be available for various platforms, including large aircraft, with reduced life-cycle costs. AFRL expects the requirements to increase as technology improves and systems become more affordable. The laboratory expects the semiconductor lasers to meet the majority of AF tactical requirements; scientists project these lasers to be in the low- to midpower range over the next decade. ATADS technology can enable other potential applications, including remote sensing of chemical and biological agents and tracker, illuminator, designator, combat identification, optical augmentation, and sensor kill capabilities.

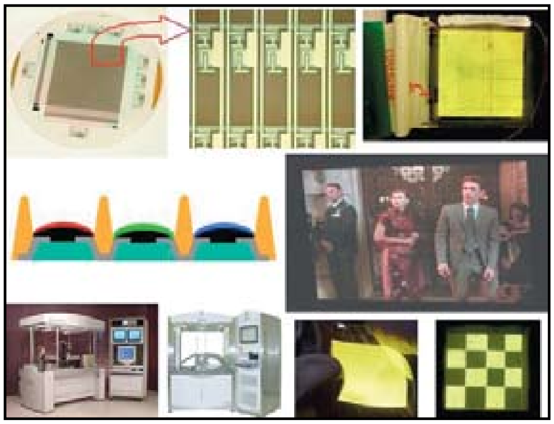
AFRL Transitions Printed Plastic Displays to Army

Payoff

AFRL managed a $22 million, 4-year effort to develop plastic displays. The resulting technology became the foundation of the $93.7 million Flexible Display Center at Arizona State University (ASU), established in 2004 in the Research Park area of ASU's campus.

Accomplishment

AFRL developed printed plastic displays (PPD) and transitioned the technology to the US Army's Future Concept Warrior program. The Army picked eight technologies critical to future capabilities; chosen technologies included AFRL's amorphous silicon thin-film transistors active matrix (AM) polymer light-emitting diode (PLED) technology for the soldier visualization system. The combined set of technologies created in this effort enabled affordable fabrication of flexible polymer organic light-emitting diode displays in arbitrary sizes by means of high-speed, roll-to-roll print manufacturing processes. Manufacturers fabricate all current production displays on fragile glass substrates in a batch process. The PPD technology may enable disposable displays and integration of visualization systems into gear already carried.



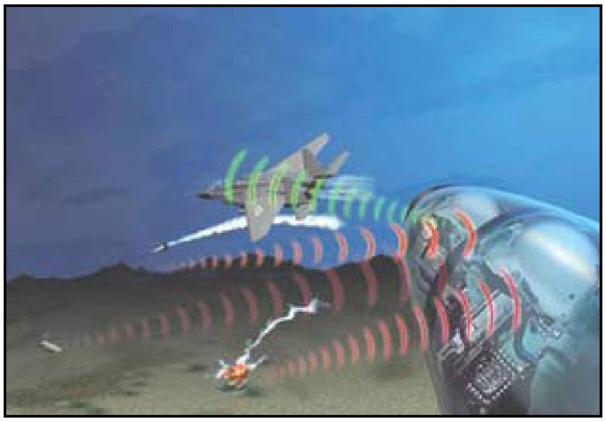
Background

AFRL managed a government/industry team that created the technology to fabricate full-color PLED displays via ink-jet printing over an AM electronic backplane constructed on plastic. The Defense Advanced Research Projects Agency; DuPont Displays; Honeywell, Inc.; FlexIC, Inc.; and Princeton University cofunded the 4-year effort.

AFRL Demo Highlights Advantages of 3-D Audio

Payoff

AFRL developed advanced, three-dimensional (3-D) audio display technology to improve pilot performance by adding realistic directional cues to the warning tones and radio signals presented in the cockpit. AFRL is now working directly with academia and industry partners to help transition this valuable new technology to military applications in command and control centers and in fast-jet aircraft such as the F-35.



Accomplishment

A team of AFRL scientists traveled to Lockheed Martin to set up a demonstration highlighting the advantages of 3-D audio technology for fast-jet aircraft. This demonstration for promoting the technology to Lockheed ultimately occurred during a 2003 Operator Advisory Group evaluation of the Joint Strike Fighter pilot vehicle interface. The demonstration feedback was so positive that Lockheed renewed its commitment to 3-D audio. The company is now in the final stages of selecting a vendor to supply this vital new technology for the F-35 aircraft.

Background

AFRL is a world leader in the design, development, and evaluation of spatial audio displays. These displays use digital signal processing techniques to synthetically re-create the acoustic cues that listeners ordinarily use to determine the locations of sound sources in their surrounding environments. For fast-jet applications, scientists can couple these 3-D audio cues with a head tracker that updates the apparent locations of the sound sources in response to the movements of the listener's head.

Security Technology Enhances Distributed Mission Operations

Payoff

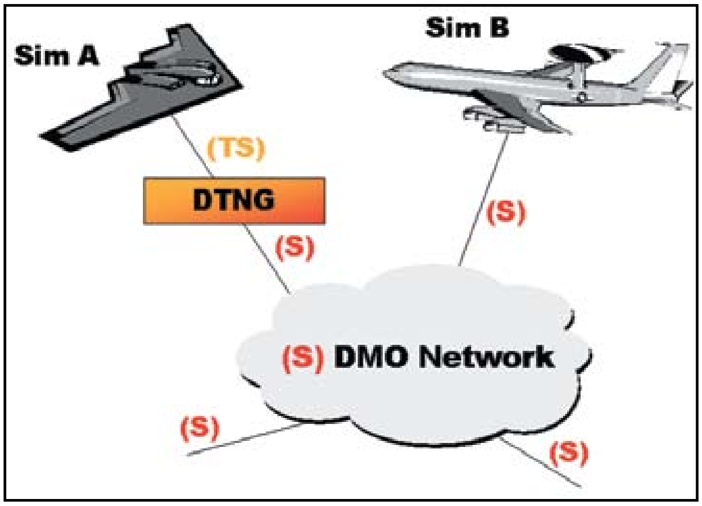
AFRL's distributed training network guard (DTNG) greatly enhances distributed mission operations (DMO), allowing distributed simulations to interoperate at their native classification levels. The DTNG delivers the capability to transfer data between high-level architecture (HLA)-based distributed simulation networks that operate at multiple security levels. This capability provides a critical element to achieve the DMO concept's full potential. The DTNG also expands the range of possible scenarios exploited by DMO and further enables warfighters to train in a distributed, secure, high-fidelity, full-mission training synthetic battlespace.

Accomplishment

The Naval Air Systems Command (NAVAIR) adopted the DTNG for its simulation facilities by contracting Trusted Computer Solutions (TCS), Inc., $1.77 million to complete the NAVAIR-unique enhancements for for the warfighter. TCS originally developed the DTNG for AFRL. The DTNG provides multilevel security for joint distributed simulations, and scientists can modify the DTNG for interoperable simulations between foreign nations in distributed coalition training, as well as in simulations between special access/special access required programs.

Background

Scientists created the DTNG program to develop and demonstrate a multi-security-level capability to enable HLA simulation federations to interoperate at different security levels. This capability allows distributed simulation systems to fully support mission readiness training and rehearsal among warfighters assigned to various weapons systems (at various classification levels) normally employed during combat operations. The operating component of the DTNG is a physical, real-time automated network guard that supports real-time, two-way data transfer between HLA simulation federations operating at different security levels.



Prior to the mission, users set the parameters for this guard via a stand-alone interface that provides the security and federation domain experts a tool to develop and review reclassification rules that govern the transfer of objects, attributes, interactions, and parameters, as well as the execution of operations across multisecurity levels. For example, experts could disguise an F-22 operating within the high-side federation as an F-15 on the low-side federation.

AFRL Upgrades Information Support Server Environment Guard System

Payoff

AFRL's latest Information Support Server Environment (ISSE) Guard, version 3.5, brings intelligence analysts and operational users a public key infrastructure-enabled cross-domain solution for e-mail and file transfers. The ISSE Guard system enables sharing of imagery, database records, formatted messages, text files, e-mail, and Microsoft® Office automation products between different security domains. The system is certified and accredited for Department of Defense (DoD) operations to enable information sharing between network domains that process information at different security levels.

Accomplishment

AFRL developed this first-of-its-kind solution while working with the office of the Intelligence Community Chief Information Officer. The Air Force Command and Control, Intelligence, Surveillance, and Reconnaissance Center sponsored this project to enable users on the Joint Worldwide Intelligence Communications System (JWICS) network to communicate with operators on the Secret Internet Protocol Router Network via digitally signed e-mail. From a distributed enterprise architecture perspective, the additional Web-enabled front-end feature for message transfers makes the JWICS network highly scalable and supportable.

AFRL converted the ISSE Guard system from a proprietary hardware platform to a full commercial off-the-shelf (COTS) environment and completely revised the configuration management, quality assurance, project management/tracking, and testing processes (internal and external). AFRL also strengthened communications internally and with its stakeholders. Additional enhancements to the ISSE Guard include improving the quality of requirements definition and tracking, user training, and operations and maintenance.

Background

Over 40 operational DoD intelligence production centers, agencies, and major commands employ more than 150 ISSE Guard systems. The initial concept for the ISSE Guard capability developed in the early 1990s to meet the needs of the DoD intelligence community and has proven to be an evolutionary development effort.

The ISSE Guard is a mix of COTS and government-developed applications. At the time of its introduction, there were no commercial products that addressed the requirements of multilevel security in or between different domains. Researchers developed the first operational prototype using congressionally allocated, applied technology funding. They delivered the initial capability in 1994 to the US Air Forces in Europe headquarters to share imagery products between domains. The system evolved to become the ISSE Guard. Through the late 1990s, the system grew from a basic application for imagery transfer into a product capable of processing a wide array of data types.

Organically Assured and Survivable Information Systems Architecture Withstands Cyber Attacks

Payoff

Over the past 5 years, the Defense Advanced Research Projects Agency (DARPA) has funded a series of AFRL programs to develop tools and technologies for detecting, containing, and/or tolerating cyber attacks while enabling systems to correctly continue mission-critical functions. The Organically Assured and Survivable Information Systems (OASIS) Demonstration and Validation (Dem/Val) program represents one such effort.

Accomplishment

The OASIS Dem/Val program objective was to integrate, demonstrate, and validate the composition of cyber security technologies using a prototype AFRL-developed Joint Battlespace Infosphere (JBI) supporting a prototype mission-critical application. The mission-critical application's two operational contexts involved (1) a focused Air Operations Center (AOC) mission planning, replanning, and execution scenario based on weather and chemical weapon effects/impacts; and (2) an integrated Combat Air Force/Mobility Air Force mission planning scenario based on theater airspace deconfliction and weather impacts to support the AOC mission plan. AFRL's role was to provide DARPA a realistic, flexible environment for integrating, demonstrating, and validating OASIS and other technologies.

Through a DARPA-funded AFRL contract, BBN Technologies (Cambridge, Massachusetts) created a survivable systems architecture that combined various technologies to execute the mission-critical application and enable its continued operation through a wide range of known and future cyber attacks. For the final demonstration and validation exercise, two nation-state-caliber Red Teams (comprising National Security Agency, Sandia National Laboratories, and Cyber Defense Agency participants) launched cyber attacks against BBN's survivable, JBI-based, mission-critical application—12 hours a day for 4 days—while the application simulated cooperative planning of the next day's air operations mission. The purpose of this exercise was to evaluate the application's defensive capability against a well-funded Red Team attack. Throughout the exercise, the application successfully performed techniques for avoiding single points of failure, exploiting diversity, dispersing and obscuring sensitive data, gracefully degrading, and deceiving attackers.

Background

The OASIS Dem/Val program was a joint effort between DARPA and AFRL. DARPA funded the research and integration of the cyber security technology, while AFRL designed and implemented the prototype JBI system and supplied the prototype, JBI-based, mission-critical application. The achievements of this DARPA/AFRL partnership provide the Department of Defense with a pathfinder for engineering robust survivable systems and realizing security and survivability in a JBI publish/subscribe architecture. Leveraging all relevant technologies available to date, OASIS employed first-, second-, and third-generation security mechanisms (including commercial off-the-shelf solutions), applied them to a realistic mission-critical application, and validated their collective ability to achieve a higher level of information assurance (availability and integrity).

AT3 Program Successfully Demonstrated

Payoff

Responding to a critical warfighter need to accurately locate time-critical targets such as surface-to-air missile systems, AFRL and the Defense Advanced Research Projects Agency jointly funded the Advanced Tactical Targeting Technology (AT3) program. The program successfully demonstrated the capability to passively detect and accurately geolocate enemy air defense radar systems faster and more precisely than currently achievable.

This technology bridges the gap between reactive suppression and preemptive destruction, a key requirement for air dominance. The direct benefit to the warfighter centers on improved standoff capability to quickly and accurately target precision-guided munitions to destroy mobile air defense units.

Accomplishment

The AT3 program team built and tested a prototype system capable of acquiring, recording, and correctly identifying the highest priority threat emitters verified through open-air flight testing. The AT3 system used multiple radio frequency sensor platforms communicating via tactical data link to detect and geolocate enemy threat emitters. A significant part of the test evaluated the system capability against multiple, identical threat emitters operating at nearly the same frequencies. The team verified system performance incrementally at various stages of development and integration—first in the laboratory, then through ground tower testing, and finally, via open-air testing.

The system successfully acquired and identified all threat emitters tested during single and multiple emitter tests. The system successfully demonstrated a flexible, open-network approach incorporating multiple platform detections, thereby producing more accurate geolocation of combat threats.

Using a concept of operations with far-reaching potential for the warfighter, the program further demonstrated that nondedicated aircraft could simultaneously satisfy suppression of enemy air defense (SEAD) and electronic support measures (ESM) requirements when equipped with a sensor interconnected by a single, real-time network.

Background

To give the warfighter the ability to replace the current tactic of reactive suppression with aggressive preemptive destruction of enemy threat emitters, military aircraft in the current and future inventory must support the SEAD and ESM mission.

The AT3 program successfully demonstrated that current and future platforms equipped with an ESM sensor and processor interconnected by a single, real-time network can concurrently satisfy dedicated mission and SEAD requirements. AT3 was the first program to allow a shift from reactive suppression to preemptive destruction. This shift provides passive, cooperative-platform, emitter geolocation of sufficient precision and timeliness for lethal SEAD targeting from a nondedicated platform aircraft with a system requiring minimal aircraft modification.

AFRL Developing Common Situation Awareness System for SOF Aircraft

Payoff
AFRL is designing the common situation awareness (CSA) system for integration into the current special operations forces (SOF) aircraft. The system will provide enhanced threat and CSA for missions related to interdiction, close air support, combat search and rescue, and infiltration/exfiltration.

Accomplishment
The CSA system is an AFRL technology demonstration program. AFRL teamed with Lockheed Martin, Northrop Grumman, and Raytheon to successfully complete the installation, integration, ground test, and flight test of the CSA Phase I flight demonstration roll-on/roll-off rack system on an Air Force Special Operations Command MC-130P Shadow aircraft. The flight test successfully demonstrated improved aircrew situation awareness, which provided real-time transfers of threat, imagery, and survivor data into/out of the cockpit; automatic route replan; beyond-line-of-sight threat detection and correlation; and secure tactical air-to-air and air-to-ground digital data links. The team monitored the flight test progress in real time using the ground station's big-screen moving map display.

Background
The test involved two flight demonstrations. The first flight demonstration tested the specific CSA capabilities, including satellite communication transmission of imagery into/out of the cockpit and secure data links with the virtual A-10. The second flight demonstration tested the capabilities to accomplish a representative MC-130P infiltration/helicopter refueling/combat search and rescue (CSAR) mission. In this flight test, a King Air 218 aircraft flew 2,000 ft above the MC-130P and acted as a surrogate helicopter. The CSA system ensured the successful completion of the simulated airdrop, helicopter refueling, and CSAR mission.

Successful Battlespace Laser Detection System Flight Test

Payoff

The AFRL Battlespace Laser Detection System (BLADES) project brings vital defense capabilities to the warfighter. The BLADES pods successfully recorded laser threats and laser hazard assessments on aircraft under various engagement geometries and engagement ranges, ultimately passing a major milestone in the BLADES development effort. These pods will become an integral part of aircraft by protecting pilots and providing feedback for countermeasures.

Accomplishment

Within a year, the AFRL team managed the pod's design, testing, and flight certification. Pilots participated in the development of the pod's design requirements. The team's goal during testing was to validate the measures of effectiveness and performance. The team met all test objectives and will use a full analysis of the flight test data to map the BLADES operational performance for each aircraft and mission profile.

AFRL developed BLADES to provide an operational tool for the assessment of laser threats that are hazardous to crew and expensive optical targeting assets. The system monitors the platform environment, capturing laser threat signatures and logging laser exposures for postmission assessment. The BLADES data products are applicable to mission planning, eyewear deployment, threat avoidance, eye damage assessments, and intelligence collection. The internally mounted pods also allow multiple airframes to carry the system.

Background

The BLADES project began 3 years ago as an Air Force initiative to provide aircraft and aircrews with an initial capability to detect and characterize battlespace laser threats. The ability to characterize battlespace laser threats allows users to tailor protective measures to the threat. It also provides the opportunity to adjust tactics to negate or avoid the threat. The focus of the effort is to develop technologies, tools, and technology trade-off assessments for laser threat characterization.

Sustainment

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Air

Cyberspace

Emerging Technologies

Technology Transfer

AFRL Delivers C-17 Emergency Escape Door to Warfighter

Payoff

Through the Advanced Aluminum Aerostructures Initiative (AAAI) program, AFRL is working to cut production costs for advanced aluminum aerospace structures for both the Department of Defense and commercial aircraft companies. AFRL's new C-17 emergency escape door design contains fewer parts and saves manufacturing costs over previous C-17 escape door designs.

Accomplishment

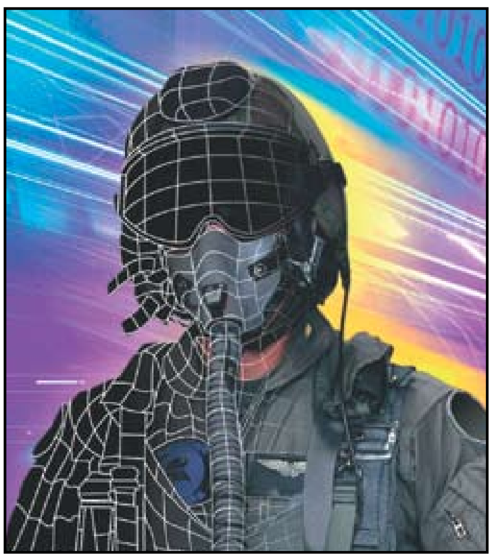
AFRL partnered with the aluminum producer Alcoa (the primary contractor) and Boeing (the C-17 manufacturer) to redesign the C-17's emergency escape door. The original escape door was a built-up aluminum structure consisting of 113 parts, whereas the new door is forged and high-speed-machined from a single piece of aluminum and has only 21 parts. The process for fabricating the new door will save an estimated 30% in manufacturing costs over the old model.

Background

AAAI endeavors to streamline the design process by involving both the material manufacturer and the airframe manufacturer in all phases of product development. AFRL teamed with Alcoa, Boeing, Lockheed Martin, and Northrop Grumman with the ultimate goal to cut the installed cost of aluminum aerostructures by at least 50%, reduce associated maintenance requirements, achieve lower life-cycle costs, and increase performance. The C-17 escape door was the first AAAI effort.

AFRL Implements Advanced Human Performance Modeling in F-15E Mission Training Center

Payoff
AFRL's Combat Automation Requirements Testbed (CART) program produced an advanced human performance modeling (HPM) tool known as WARRIOR (warfighter-realistic, interactive operational representation). Introducing HPM technology early in weapons systems development can significantly increase efficiency and reduce costs for many diverse operations.



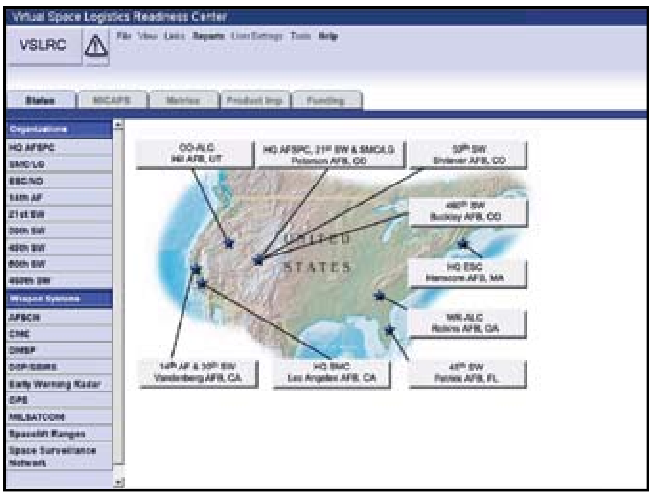
Accomplishment
WARRIOR facilitates development and integration of high-fidelity human operator models, called soft warriors, with distributive virtual simulation environments. The CART team is successfully using soft warriors and applying other CART-developed HPM to create semiautonomous forces that simulate combat search and rescue, ground and airborne forward air controllers, and time-critical target cell entities. Additionally, CART is implementing WARRIOR technology in the F-15E Mission Training Center, which will provide four-ship sets of support simulations and tools for use in the distributed mission training (DMT) environment. Integrating the models with constructive virtual simulations in DMT combat exercises allows F-15E crews to interact and train in more realistic environments and prepares them for real-world conflicts.

Background
From simulated flight decks to war zones, CART's WARRIOR technology fills a significant void in current constructive simulations. The technology provides detailed representations of the timing, accuracy, workload, decision making, and goal-directed behavior associated with human performance. WARRIOR incorporates these capabilities into an easy-to-use, task network modeling framework; permits the Air Force's constructive simulations to become warfighter-centric; and provides a highly realistic environment for combat tactics and concept of operations training.

AFRL Provides Space Logistics Integrated Picture to Air Force Space Command

Payoff

AFRL developed an online graphical user interface software program for Air Force Space Command (AFSPC). Space logisticians can now view all ground system status reports from a single, Web-based location. By providing easy access to ground system status, the software release improves awareness regarding AFSPC assets worldwide.



Accomplishment

Space logisticians around the world can now use a common online interface to post and review key logistics reports on ground system status and repair times. AFRL established this simplified access method by providing a single integrated space picture, known as the Smart System Technologies for Operational Virtual Space Logistics Readiness Center Web page. Online visibility of operational, equipment, communication, and logistics status is critical for both air and space forces. This program will help to define and display metrics for identifying the impact of logistical actions on operations for both the near and long term.

Background

AFSPC took the first step towards promoting a better understanding of its facilities' status and increasing its ability to obtain the funding required to fix identified problems. In the past, AFSPC relied on time-consuming communications such as the telephone and e-mail to determine the status of its ground systems.

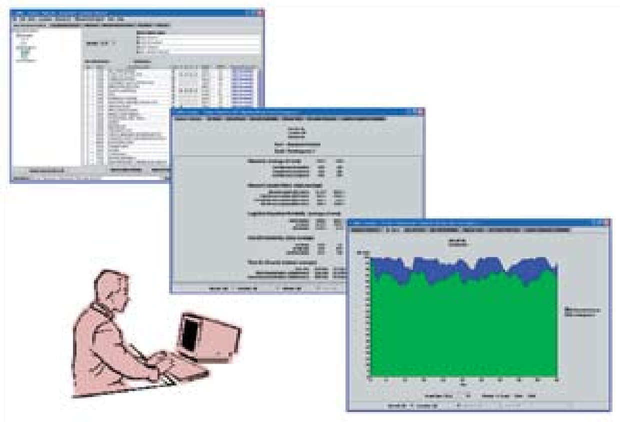
AFRL Develops Mobility Aircraft Availability Forecasting Model

Payoff

AFRL transitioned an innovative modeling capability to Air Mobility Command (AMC). Engineers investigated the factors that significantly impact mobility aircraft availability and designed an object-oriented framework that captures these critical elements. Given this framework, mobility planners can employ the mobility aircraft availability forecasting (MAAF) model to develop experimental scenarios in which researchers can assess varying resource levels and mission profiles. This modeling approach could provide better aircraft readiness estimates associated with alternative operational scenarios.

Accomplishment

AFRL engineers studied the feasibility of using object-oriented simulation techniques to forecast the number of available aircraft given projected mission requirements. The MAAF proof-of-concept model demonstration emphasized that the object-oriented approach could quickly and accurately forecast the impact of various courses of action (COA) on aircraft availability. AFRL teamed with industry and academic experts to study the factors that significantly impact aircraft availability. From this basic research, the team designed an object-oriented framework to forecast aircraft availability by modeling mobility aircraft as they transition throughout the air mobility network.



Mobility Aircraft Availability Forecasting (MAAF) Model Screen Displays

AFRL's innovative modeling approach captures key mobility elements such as mission types, varying resource levels at en route/home station locations, and aircraft-specific minimum essential subsystems lists. The future MAAF model will incorporate an analysis capability that will allow planners to identify logistical bottlenecks while evaluating operational alternatives. Today's proof-of-concept model demonstrates that analyzing multiple factors in a simulation can improve the accuracy of aircraft availability forecasting. This capability may enable better use of logistical resources, more effective aircraft scheduling/routing, and improved COA analysis.

Background

AMC's director of logistics is responsible for ensuring the mobility fleet is available to accomplish its mission. Despite the critical need to efficiently use aircraft and personnel, AMC mobility planners lacked an automated simulation method for predicting the impact of logistics-related factors on mobility aircraft availability in proposed operational scenarios.

AFRL Supports C-5A Evaluation Program

Payoff

AFRL materials integrity experts are providing support to a joint effort between the C-5 Systems Group, the Warner Robins Air Logistics Center (WR-ALC), and Air Mobility Command (AMC) to analyze C-5A aircraft components. AFRL will provide data that AMC and the C-5 Systems Group need for determining current aircraft capabilities and identifying ways to make improvements and eliminate future concerns with the C-5A. AFRL has a legacy of providing quick-response capability in important material areas, including failure analysis of metallic, composite, and electronic components, as well as nondestructive evaluation of structural and nonstructural aircraft components.

Accomplishment

This program represents the first study of this kind for the C-5A, the Air Force's largest cargo aircraft. General John W. Handy, AMC commander, requested that materials experts perform the study both to determine whether the aircraft's structure and components fulfill original design predictions and to evaluate long-term C-5A maintenance requirements. AFRL provided guidance during development of the project's analysis requirements, verified and validated the capabilities of several subcontractors participating in the project, and will evaluate several C-5A components to determine their structural integrity.

Background

The program's threefold purpose involves (1) analysis of integral aircraft components to assist AMC in identifying the magnitude of future fleet component repairs and replacements, (2) unexpected structural integrity concerns, and (3) identification of validation of both Aircraft Structural Integrity Program process and the fleet structural maintenance plan. AFRL materials integrity experts are providing independent audits of several subcontractors who participated in this project. These audits will verify the organizations' ability to document and report results that WR-ALC, AMC, and the C-5 Systems Group can use. The team will enter all of the collected data into a damage tolerance analysis program, which will allow experts to make accurate life predictions for the aircraft and its components.

In addition, AFRL identified several components for in-house evaluation, including the inboard engine pylon attachment fitting, the aft pressure bulkhead, and the contour box beam fitting. Scientists identified each of these components as a high-priority component within its respective body section. Testing will determine fatigue and stress corrosion cracking issues with these components.

AFRL Experts Investigate Airfield Pavements

Payoff

A team of AFRL experts successfully assessed a portion of the airfield runway at Langley Air Force Base (AFB), Virginia, providing valuable support to the Air Force (AF) Civil Engineering program. AFRL experts are exploring technologies that will promote rapid restoration of flying operations in the field and advance AF technology and research efforts. This quick-response capability offers innovative, timely, and affordable technical assistance to the civil engineering community.

Accomplishment

AFRL technicians used ground-penetrating radar (GPR) and electronic cone penetrometer (ECP) technology prototypes to determine whether soil anomalies were the cause of cracks in the runway's shoulder slab. They also investigated the integrity of the airfield's keel section. The team collected data to determine the cause of the condition and provided several nondestructive solutions to remedy the abnormal or weakened runway portions. This field evaluation provided valuable information to further refine the technology development effort.

The AFRL team assessed selected airfield pavements at Langley AFB for anomalies such as voids and weakened underlying material. The assessment included a visual inspection of the pavement, data gathering from local sources, grid pattern and focused GRP scans, coring and ECP testing, and data analysis and reporting. GPR testing indicated that the underlying material surrounding a storm drainpipe was not adequately supporting the runway shoulder section. AFRL specialists concluded that previous rains, raised water table events, and/or drainpipe leaks had saturated the soil, causing a loss of soil support that led to cracks in the slabs. ECP testing results supported these conclusions.

Background

GPR and ECP data showed that airfield closure was not an immediate requirement. Instead, the AFRL team suggested foam injection or grouting as a temporary remedy until Langley AFB could close the airfield to replace the damaged slabs. The team further recommended lifting the damaged shoulder slabs during the replacement process instead of wrecking the slabs. In addition, they suggested that technicians examine the underlying material for signs of piping and subgrade disturbance, which would prompt further excavation for visual inspection of leakage in the storm drainpipe system.

AFRL Evaluates Thermal Stability of Dielectric Coolants for Use in High-Temperature Environments

Payoff

AFRL nonstructural materials experts completed testing that confirmed the thermal stability of dielectric coolants to be used in the Joint Strike Fighter's (JSF) high-temperature environment. Each of the coolants identified on the qualified product list, which includes 12 fluids manufactured by 8 companies, passed the high-temperature stability testing. Test results revealed no significant change in viscosity, acidity, or weight, and no breakdown in any of the 12 identified coolants. Researchers concluded that the fluid will perform at both the temperatures and the operating duty cycles that the aircraft and its components require.

Accomplishment

AFRL experts conducted several high-temperature stability tests that exposed each coolant to 100 hours of testing at temperatures as high as 200°C. The fluids showed no evidence of deterioration at this extremely high temperature. Members of AFRL's Fluids and Lubricants Group reported these results during a conference with JSF engineers from the Air Force (AF), the Navy, and Lockheed Martin. Though the AFRL nonstructural materials team did not expect the fluid to perform successfully at these high temperatures, they did predict the fluid would demonstrate adequate thermal stability up to 232°C with no noticeable decrease in coolant performance at these higher temperatures. Engineers will monitor fluid performance during the development program by periodic sampling. AFRL offered to conduct any follow-on sample analysis.

Background

Dielectric coolants are a critical safety-of-flight material for all AF aircraft. Today's sophisticated electronic systems (e.g., flight control, target acquisition) rely on high-performance coolants to ensure proper operation. The JSF program is the Department of Defense's focal point for defining affordable next-generation strike aircraft weapons systems for the AF, Navy, and Marines, as well as US allies. The program's focus is affordability—to reduce development, production, and ownership costs of the JSF aircraft family.

Currently in development stages, Lockheed Martin's JSF is a multimission, supersonic aircraft designed to meet all service requirements with enhanced lethality and survivability and reduced vulnerability. According to Lockheed Martin, the JSF's unique, multiple-variant design pushes the threshold of fighter technology far beyond current limitations. The AF variant of the technology takes multirole fighter performance to new levels, with more stealth, increased internal fuel range, and advanced avionics. Dielectric coolants maximize heat transfer characteristics in aircraft systems by dissipating heat from high-energy electronic components.

AFRL Supports Development of Composite Material Fire Safety Training Course

Payoff

The AFRL Fire Research Group created the Composite Fire Safety Initiative to improve the safety and effectiveness of Air Force, Department of Defense (DoD), and civilian firefighters. The Strengthening the Mid-Atlantic Region for Tomorrow (SMART) Team led the initiative, in which the laboratory united fire science and education experts from the University of Delaware, the University of Maryland, the Air Force Civil Engineering Support Agency, the Federal Aviation Administration, the National Institute of Standards and Technology, and Naval Air Systems Command. Pennsylvania Congressman Curt Weldon sponsored the effort, which resulted in the development of the Composite Material Fire Safety training course. This course will provide firefighters with the necessary education and methodologies to rapidly and safely extinguish composite material fires.

Accomplishment

Instructors at the DoD Fire Academy, Goodfellow Air Force Base, Texas, will receive training and certification, along with the opportunity to incorporate the course into their curriculum. The course stresses the importance of recognizing composite structure in safely and effectively extinguishing fires involving the materials. It also highlights cautious handling of composite material incidents, use of proper personal protective equipment, and utilization of the best available decontamination techniques. Scientists expect the program to reduce potential injuries and deaths related to complications firefighters may encounter when combating such fires. More than 10,000 DoD firefighters and first respondents may receive the training, and AFRL expects thousands of civilian firefighters to benefit from the program as well.

Background

SMART, a collaboration between federal and state government and science and technology leaders, originated in the mid-Atlantic science and technology community. Congressman Weldon's staff asked AFRL's Fire Research Group to provide valuable oversight and input due to AFRL's extensive experience in exploratory and advanced research in fire suppression and crash/rescue technologies. The group has been instrumental in fire retardant material research and development, large-scale explosion mitigation fire suppression, and integrated advanced firefighter technology development programs. The group is well known throughout the DoD and academic and civilian communities as a center of fire research excellence.

The completed program will provide all firefighters with an understanding of how composite materials are structured, an update on factors such as composite burning characteristics, the degrees of fire damage, and what firefighters can expect when encountering these fires. Students will review hazardous material response/mitigation and decontamination procedures specific to composite materials. They will also evaluate events that occur during a composite material fire and explore the dangers firefighters face during emergency situations. Finally, they will review firefighting tactics and learn the most effective agents and applications for combating composite fires.

AFRL Upgrades Eddy Current Inspection Systems

Payoff

AFRL engineers delivered a major configuration upgrade to the Eddy Current Inspection System (ECIS) used at Oklahoma City Air Logistics Center (OC-ALC), Tinker Air Force Base, Oklahoma. The upgrade improves system reliability, increases throughput, and frees floor space, allowing OC-ALC to improve F100 and F110 engine turnaround and to accept future F119 and F135 engine workloads. Additionally, improved inspection technologies with more accurate stress analysis data will reduce costs by extending the life of Pratt & Whitney and General Electric aircraft engine components.

Accomplishment

AFRL's upgrade involves consolidation of system electronics and wiring from a three-bay cabinet design into a single-bay cabinet. ECIS is a state-of-the-art inspection station for the Air Force's gas turbine engine disks. AFRL supports the ECIS system with upgrades as part of the Engine Rotor Life Extension (ERLE) program. ERLE is an AFRL initiative to mature and implement technologies that safely extend component life and also increase depot inspection capability, reliability, and efficiency. A complement to the ECIS single-bay design is the sewing stitch enhancement, which scientists implemented on an F100-GE-129 high-pressure turbine disk. This enhancement has shown a 65% decrease in inspection time on the dovetail slot features of a disk.

Background

The current ECIS station consists of a large electronic manipulator arm atop a massive granite block. An engine disk sits on a turntable that rests on the block and rotates as needed. The manipulator arm carries a probe and maneuvers over, around, and through the various areas of the disk. Using an assortment of eddy current probes, the system collects information from the engine disk and indicates defects in different geometric features on the disk.

The new system provides upgraded communications between the station computer and robot to enable faster and more efficient engine parts inspection. Scientists have integrated digital filters into the station software to replace the existing hardware analog filters, which have poor reliability and require significant system downtime during replacement.

AFRL Validates Use of Hydraulic Fluid Purification Technologies

Payoff

AFRL scientists and engineers are functioning as part of the Aeronautical Systems Center (ASC) Aging Aircraft System Squadron's Hydraulic Fluid Purification (HFP) Integrated Process Team (IPT) to validate the use of HFP technologies at Air Force (AF) facilities. They expect the technology's implementation to improve fluid quality, reduce waste streams, extend component life, reduce maintenance, and improve system performance.

Accomplishment

AFRL fluid and lubricant experts, along with ASC's Aging Aircraft and Pollution Prevention Office, are initiating a 2-year field service evaluation program to collect and assess data to deliver the results to major AF commands. They expect testing and system validation to show that HFP technology can significantly reduce the hydraulic fluid waste stream, save AF maintainers considerable time and money, and improve aircraft and aerospace ground system performance.

The HFP IPT will test both Pall Corporation's and Malabar Corporation's portable fluid purifiers at operational AF maintenance units and will test hydraulic fluid samples to determine the purification effectiveness. The team will address the system's overall suitability and will provide preliminary estimates of its overall impact to waste streams and costs associated with various types of operational units. Several aircraft system program offices, including the C-5, C-17, KC-135, B-1, F-15, and F-16, have approved the use of purified hydraulic fluid in their aircraft.

AFRL and the Aging Aircraft Office evaluated the existing cleanliness levels of approximately 10% of AF aircraft and mules (servicing carts). They will test specifically for water, particulate, solvent, and barium contamination. Reserve and training bases in Florida, Michigan, and Ohio received hydraulic fluid purifiers.

Background

The AF established the HFP IPT to conduct a formal three-phase evaluation of the common commercial HFP practice. The effort was a pollution prevention project designed to validate HFP and implement purified hydraulic fluid use in AF aircraft and aerospace ground equipment. The HFP IPT plans to reduce the second-largest fluid waste stream in the AF by providing timely, thorough, factual data to the aerospace community to support and implement aircraft HFP.

AFRL is performing critical work during every phase of the HFP project. The laboratory's efforts are in response to critical program needs, such as providing competition for qualified purifiers, increasing the availability and lowering the cost of the technology, encouraging use of the HFP process to reduce hazardous waste, and demonstrating a return on investment across Department of Defense aircraft ground support equipment operations and Air Logistics Center hydraulic depots in less than a year.

AFRL Delivers Alternative Approaches for Corrosion Prevention and Surface Damage Control in Rigorous Environmental Conditions

Payoff

AFRL corrosion experts teamed with Warner Robins Air Logistics Center to assess the environmental effects of extended operations in the Southwest Asia (SWA) Area of Responsibility (AOR). The SWA AOR comprises 27 countries, including Iraq and Afghanistan. AFRL will use the assessment results to ensure the Air Force (AF) has the best available materials and cost-effective ways to improve corrosion protection for systems and materials while maintaining environmental compliance. The team's efforts are improving the readiness, cost, and structural integrity of AF systems that are critical to the US' missions in various SWA locations.

Accomplishment

In AFRL's ongoing assessment, the Air Force Corrosion Prevention and Control Office team observes how sand and dust affect AF weapons systems and sensitive support equipment, analyzes sands from various locations, and compares corrosion prevention and control policies and inspection requirements from prewar to present-day operations. As the assessment progresses, team members provide progressive and alternative approaches to corrosion prevention and control, wet and dry cleaning, and aircraft maintenance in rigorous environmental conditions.

AFRL provided SWA AOR units with effective sealants, sealing tapes, electrical protection, and gel-type gasket materials. All of these on-the-spot recommendations provided solutions to critical equipment operation challenges and demonstrated effectiveness in the desert environment. The team evaluated environmental effects during the SWA assessment to analyze corrosion, erosion, and dust intrusion; corrosion prevention and control policies; inspection requirements and field depot workloads; corrosion prevention compounds; the effectiveness and frequency of wash cycles; and cleaning methods.

Background

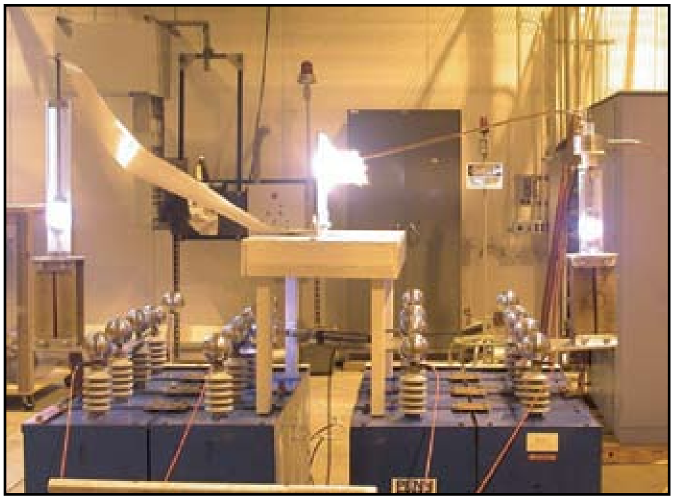
SWA AOR conflicts present the AF with unique aircraft structure, system and subsystem corrosion, and degradation challenges. An aging aircraft fleet that operates far beyond its intended service life compounds corrosion problems. Corrosion concerns also extend beyond aircraft to include ground support equipment, vehicles, munitions, and mobile communication/electronic equipment.

Extended desert operations subjects modern AF equipment to a record level of damage resulting from the invasion of very fine sand and dust into aircraft, weapons systems, and support equipment. The wear from the abrasive sand and dust causes premature parts replacement. Additionally, random sampling of contamination in deployed equipment shows high levels of corrosive anions. In situations where sand/dust contamination has a high concentration of corrosive anions, the corrosion rate of a wide variety of materials can accelerate.

AFRL Provides Solutions for C-17 Lightning Strike Protection

Payoff

AFRL provided solutions for lightning attachment event mitigation and damage repairs for the C-17 transport aircraft. AFRL used its pulse current generator facility to deliver impulse currents of approximately 20,000 amps peak amplitude to C-17 prototype structures. AFRL's unique facilities and expertise provided a rapid and cost-effective evaluation of various nanomaterial-based composite solutions to the C-17 lightning attachment problem.



Accomplishment

AFRL developed specialized composite panels that employ nanomaterials in their fabrication. Each prototype carbon composite panel has its own unique construction, with an emphasis on using layers of nanofilamentary metals, metal-coated carbon nanotubes, and nickel nanostrand veils. Prior to testing the panels' high-current impulse, the laboratory accomplished full characterization of surface and subsurface morphology for each prototype. AFRL employed its unique pulse current generator facility to deliver impulse currents of about 20,000 amps peak amplitude in an effort to simulate attachment events on the prototype panels. Laboratory personnel reconfigured the impulse test facility and designed customized panel mounts to simulate the lightning attachment event.

Background

The aircraft's current hybrid composite material design utilizes an embedded conductive copper mesh that provides a level of lightning strike survivability; however, repairing lightning attachment sites in the field is a difficult task, and the repair process does not ensure maintained electrical bond continuity. Scientists typically use the pulse current generator to perform research and characterize transient magnetic fields, which result from the operation of advanced directed energy weapons on flight vehicles. AFRL manages and executes research and advanced development programs in power generation and systems integration technologies.

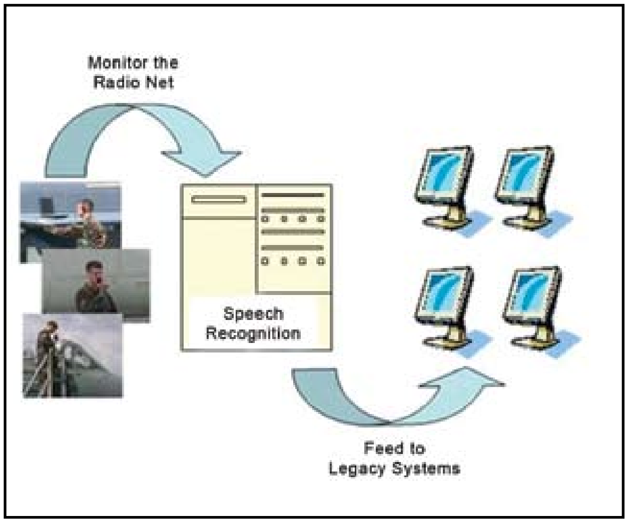
AFRL Applies Voice Recognition Technology to Aircraft Maintenance

Payoff

Applying voice recognition and activation technology to the aircraft maintenance environment increases the accuracy of data, decreases the time required to input data, and ultimately enhances the effectiveness of technicians. Improved data accuracy means that historical maintenance data becomes more meaningful and useful for analysis purposes. In terms of time and effectiveness, voice recognition and activation technology dramatically decreases the time it takes a maintainer to document maintenance actions, ensures the timeliness of status information, and often decreases the manpower needed to complete particular maintenance tasks.

Accomplishment

Kelley's Logistics Support Systems (KLSS), Inc., transitioned the voice recognition technology, which the company developed under an AFRL Phase II Small Business Innovation Research (SBIR) effort to provide voice input and navigation capability for two separate Air Force programs: Point of Maintenance (POMX) and B-2 Speech-Enabled Mapper. Using POMX, technicians use their voices and handheld computers to document maintenance actions at the job site, significantly improving data accuracy and integrity. Similarly, technicians using the B-2 Speech-Enabled Mapper rely on voice recognition and a portable computer to document defects in the low-observable material covering the B-2. They navigate the application using voice commands, capturing pertinent information through voice recognition instead of a keyboard or similar data input device. This hands-free environment allows each technician to document discrepancies, both reducing the potential for data entry errors and decreasing the time and manpower required to complete the inspection.



Background

Under the SBIR program, KLSS has researched and developed various software tools using voice recognition technology since 1998. This SBIR contract, FM-Net, initially researched the feasibility of using voice recognition technology to document flight line status information captured passively through radio transmissions. The resulting Aircraft Status Reporting Tool proved to be 90% effective when tested in a real-world flight line environment. Building upon this research foundation, KLSS successfully applied voice recognition technology to aircraft inspection and maintenance documentation processes, as well as voice activation capability for navigating electronic technical orders, emergency checklists, and various maintenance applications. KLSS and AFRL subsequently transitioned the results of this SBIR effort to the commercial sector, where the technology has helped ophthalmologists document eye examinations in a hands-free mode.

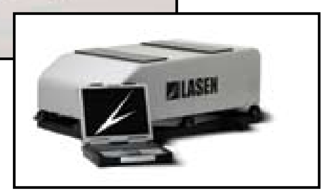
AFRL's Laser Technology Leads to Successful Airborne Lidar Pipeline Inspection System

Payoff

AFRL recently completed a four-phase project that resulted in a differential absorption light detection and ranging (lidar) system that progressed from a conceptual laboratory demonstration to a unit suitable for field use. AFRL initially designed the system to monitor Air Force base environmental cleanups and dump sites and detect underground diesel fuel tank leaks.

Accomplishment

The Airborne Lidar Pipeline Inspection System (ALPIS) is a differential absorption lidar system that remotely detects, measures, and maps atmospheric concentrations of hydrocarbons, such as methane and ethane (core components of natural gas), associated with natural gas line leaks. ALPIS can detect the presence of particular chemicals from a safe distance, a critical capability in numerous military and commercial applications.



In 2004, LaSen (Laser Sensors), Inc. (Las Cruces, New Mexico), demonstrated ALPIS' capabilities during Department of Energy-sponsored tests of remote leak detection technologies. In these tests, ALPIS inspected a simulated pipeline that had varying degrees of leaks distributed along its route. Based on the test results, researchers determined that ALPIS successfully detected multiple leaks ranging from 100 to 5,000 standard cubic feet per hour with a low rate of false positives. In 2005, LaSen successfully executed a commercial pipeline inspection contract potentially worth over $6 million. Following this achievement, ALPIS received certification from the Federal Aviation Administration for air worthiness.

Background

Presently, the US has over 2.3 million miles of natural gas and hazardous liquid pipelines, most of which date back to the 1950s and 1960s. Estimated natural gas loss through these pipes exceeds $1.5 billion per year, a figure that excludes the costs of environmental impacts and the loss of life and property.

A Small Business Innovation Research contract funded the initial effort to construct a midwave active laser chemical remote system with potential application as a base remediation sensor. After AFRL demonstrated the system, another Department of Defense agency expanded available funding to increase the unit's capacity to identify chemicals associated with weapons of mass destruction. During this period, the Department of Transportation recognized the system's potential and provided funds to deploy the sensor on an airborne platform.

ALPIS can overlay visual images onto the lidar data, which is placed on a Geographic Information System mapping grid. Using a standard mounting bracket, scientists can mount ALPIS to a helicopter's exterior. The system transports easily between identical helicopter models and provides a rapid, accurate, and economical means of pipeline inspection.

AFRL Awards Microvascular Autonomic Composites Grant

Payoff

The study of microvascular autonomic composites is an emerging field of science that incorporates automatic responses, such as those found in biological entities, into plastic materials used for manufacturing Air Force equipment (e.g., airplanes and space platforms). This new breed of composite materials with self-healing, self-cooling, and self-diagnosing capabilities will enable equipment to survive longer, fail less often, and be more reliable and cost-effective. This will ultimately lower the frequency at which parts are replaced, as well as reduce costly maintenance procedures.

Accomplishment

AFRL recently awarded the Beckman Institute for Advanced Science and Technology (located at the University of Illinois at Urbana-Champaign) a 5-year, $5 million grant to further study biomimetic multifunctional composites, also called microvascular autonomic composites. AFRL chose the Beckman Institute to spearhead the Multidisciplinary University Research Initiative (MURI) and coordinate research teams and advisers from the University of California, Los Angeles; Duke University; and Harvard Medical School.

The research team will build upon the Beckman Institute's established scientific knowledge base related to self-healing plastics. This new technology reduces the threat of structural failure caused by microscopic cracks and fissures by automatically filling open space once a separation occurs—a process that strongly resembles the manner in which the human body automatically seals a cut or puncture.

Background

The MURI program addresses large multidisciplinary research topics representing exceptional opportunities for future Department of Defense applications and technology options. Associated grants provide long-term support for research, graduate student assistance, and laboratory instrumentation development supporting specific science and engineering research themes vital to national defense.

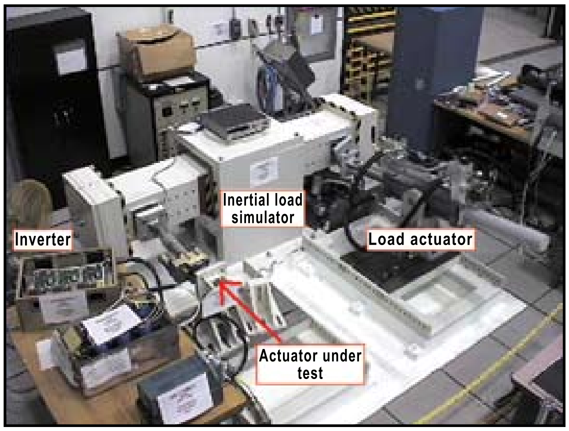
AFRL Demonstrates Integrated Prognostics and Health Management Control System

Payoff

AFRL engineers teamed with Lockheed Martin to conduct the first demonstration of an Integrated Prognostics and Health Management (IPHM) control system. This achievement is an important step towards the Air Force's (AF) goal to develop operationally responsive space (ORS) access capabilities.

Accomplishment

AFRL and Lockheed Martin used a real-time, hardware-in-the-loop simulation to demonstrate an IPHM control system. Engineers integrated a space vehicle control surface actuator representation into a simulation environment. They evaluated the IPHM control system's ability to compensate for simulated actuator failures such as heat degradation and power loss. The IPHM system successfully compensated for all introduced failures throughout a variety of scenarios, including takeoff, flight, and landing. This evaluation was the first demonstration of an IPHM control system's ability to make flight-critical system adaptations.



Background

ORS access requires a reusable space launch vehicle capable of a quick turnaround from space. The IPHM system determines the operational status of a vehicle's individual components and can help correct component failures. IPHM technology will aid in quick vehicle turnaround by readily diagnosing subsystem problems and component degradation, and indicating required corrective measures.

Hardware-in-the-loop demonstrations enable hardware assessment prior to real-world implementation. In addition to improving safety, this technique saves money and time for the AF. Simulation gives engineers a better understanding of how the hardware will respond and also eliminates absolute failures prior to real-world tests. In addition, flight simulations are more cost-effective than one actual launch, and scheduling and weather do not cause delays.

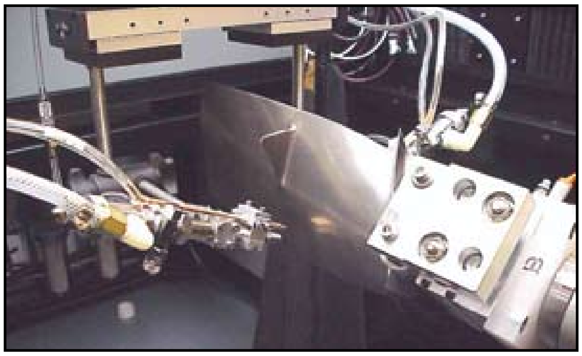
Engine Data Mining Software Provides New Capability for Air Force Engineers

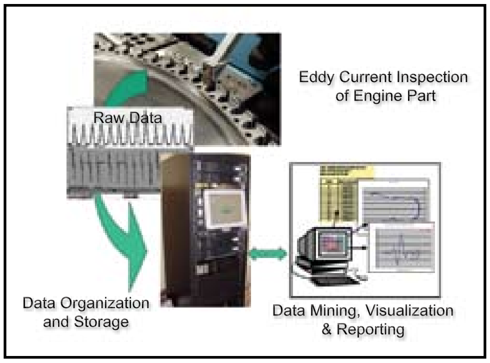
Payoff

AFRL collaborated with researchers at ISTL, Inc. (formerly InfoScribe Technologies, Ltd.), to develop a software program allowing Air Force engineers, researchers, and maintenance personnel to search through fighter jet engine inspection data more efficiently. The resulting design, known as the Intelligent Agent Architecture, allows shop managers to narrow their search for engine data, which will reach storage levels as high as hundreds (or thousands) of gigabytes per year. Users can receive electronic reports within minutes. Thus, initial estimates show that the data search and associated reporting methods will save hundreds of man-hours annually.

Accomplishment

Researchers fully developed and demonstrated the new Web-based search capability, which allows users to log in to the newly implemented inspection database and access data from any networked computer, run customized data mining agents through a Web browser, and receive reports containing desired information. Managers can define an inspection time interval, such as "Monday through Friday," and obtain reports pertaining to that period. They can also receive reports on demand or have the software automatically forward updated reports. For example, the new data mining capability can provide inspection reports on parts that cause the most frequent inspection errors or on a specific engine part's length of inspection.





Background

Scientists originally developed the Intelligent Agent Architecture search program for use with data collected from the Eddy Current Inspection System (ECIS) stations under AFRL's Engine Rotor Life Extension (ERLE) program. Under ERLE data management activities, the inspection database collects and records all inspection data from ECIS engine inspections. This includes parts information, probe information, coordinates, inspection time, and raw inspection data. This sort-and-search method provides managers with a tool to quantify and analyze the efficiency of the 31 inspection stations at Oklahoma City Air Logistics Center, Tinker Air Force Base, Oklahoma.

The Intelligent Agent Architecture also accommodates integration of other data sources. For example, ECIS data may be integrated with the Retirement for Cause database, which stores data associated with an engine part's flaw. By integrating a part's flaw information with its coordinate data and incorporating a data visualization technique, the engine owners can create parts diagrams that identify the part's flaw locations. Similarly, this existing data may be coupled with future data sources, such as engine usage data, to generate a detailed depiction of an engine's condition. The Intelligent Agent Architecture will allow integration of all data sources to enable searches for trends ranging from overall engine inspection processes to a specific engine's remaining life.

For more information contact
TECH CONNECT, (800) 203-6451

Laser Inspection Determines Strength of Bonded Structures

Payoff

The AFRL Composites Affordability Initiative developed structural inspection techniques that reduce cost and increase structural efficiency through bonded and integrated structures. Bonded structures offer many advantages to aerospace weapons systems, including lower acquisition costs, lower life-cycle costs due to the elimination of fasteners, and smoother airflow over aerosurfaces. Bonded structures also enable lighter-weight structures, which translates into increased range, speed, payload, or loiter for advanced weapons systems requiring a low structural weight percentage, including long-range strike; persistent intelligence, surveillance, and reconnaissance; and multirole, all-environment mobility systems.

Accomplishment

AFRL achieved a breakthrough in structural inspection techniques. The laboratory proved the ability to test for weak bonds and nondestructively determine a minimum strength of adhesively bonded aerospace structures. The method enables wider use of bonded structures, reducing fabrication and assembly costs up to 25% and life-cycle costs by 75%.

High-peak-power, short-pulse-length laser excitation can generate stress waves that can discriminate between weak and strong bonds in graphite-epoxy, composite-to-composite structures. The technique identifies variations in surface preparation techniques, levels of surface contamination, and/or changes in paste adhesive mixing. In numerous laser stress wave experiments, scientists found this approach to be repeatable and reliable in the detection of weak versus strong joints. This approach offers a potentially cost-effective method to ascertain a minimum predetermined load-carrying capability of a bonded joint after manufacture or during service.

Background

Scientists use bonded structures for a variety of secondary applications. However, several factors have inhibited the use of efficient bonded primary structures. One major obstacle has been the lack of a nondestructive technique to assess the strength of a bonded joint. Boeing and AFRL developed a laser bond inspection technique (patent pending). Under a Small Business Innovation Research effort, AFRL and LSP Technologies, Inc., are developing and optimizing a production floor laser bond inspection device.

AFRL Advances Aircraft Corrosion Protection for Aluminum Aircraft Surfaces

Payoff

AFRL scientists and engineers developed a nonchromated surface treatment for aluminum aircraft surfaces and structures. AFRL expects the replacement of existing chromate-containing treatments will eliminate 90% of the Air Force's (AF) hazardous waste stream. The new treatment will also reduce costs associated with disposal of the current chrome-based treatments, which are carcinogenic.

Accomplishment

AFRL collaborated with Boeing Phantom Works and the Aging Aircraft Systems Squadron to develop the nonchromated surface treatment. The team tested the new treatment through KC-135 and F-15 operational flight tests. The development of an environmentally safe, nonchromated surface treatment for aluminum aircraft structures is one of several AF initiatives providing aircraft with advanced corrosion protection that is increasingly environmentally friendly. The team also anticipates maintenance depot feedback provided in the program's second phase will improve the efficiency of the treatment application process, optimize the treatment for vehicle- and depot-specific issues, and provide critical input on the new treatment's performance with respect to current and proposed aircraft systems performance requirements.

Background

Due to the excellent corrosion-inhibiting properties of chromates, scientists have used chromate-based surface treatments, primers, and inhibitors to control and mitigate corrosion in AF aircraft. However, hexavalent chromium is a carcinogen that environmental and health regulations have recognized as hazardous; therefore, the material requires careful handling and additional disposal expense. Despite the development and evaluation of various nonchromated surface treatments, none have offered corrosion protection equal to that of chromate-based treatments.

AFRL chose the KC-135 and F-15 aircraft to represent respective transport and tactical aircraft for flight-testing the nonchromated surface treatment. They chose these systems because of the differences between the KC-135 and F-15 production environments. For example, aircraft maintainers can treat, coat, or paint the F-15 from either the hangar floor or the top of the aircraft, whereas completing these tasks for the KC-135 requires special lifts. The F-15 has several sharp contours and offers access to hatches on the exterior surface, while the KC-135's more gradual contours (with few completely horizontal surfaces) allow easier drainage of the process solution than the F-15.

AFRL-South Korean Partnership Strives to Improve Titanium Processing

Payoff

AFRL and Asian Office of Aerospace Research and Development (AOARD) programs in South Korea developed a partnership to research titanium (Ti)-related projects. This partnership has greatly improved the understanding of structure-property relationships and alloys with improved properties, as well as the development of tools needed for further improvements. AFRL-AOARD efforts are addressing the wider use of Ti alloys. AOARD programs also enable exchange visits between AFRL and overseas scientists and engineers and promote cutting-edge science and scientific interchange through various workshops and conferences.

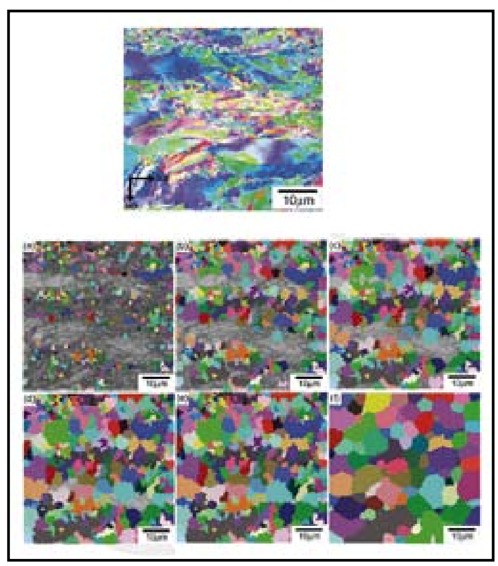
Accomplishment

AFRL researchers are seeking to understand Ti alloy intricacies, complex structures, and structure-property relationships. They are particularly interested in the relationships among processing variables and resulting structures. Well-controlled processing can lead to higher strengths; better resistance to fatigue, creep, and corrosion; and more reliable, less expensive parts production. AFRL researchers teamed with a group of South Korean metallurgists to address several of these compelling challenges.

AFRL research related to Ti processing is based on a fourfold foundation: (1) comprehensive understanding of process physics, (2) development and use of novel processes, (3) use of advanced tools for characterization, and (4) development of advanced modeling techniques. AFRL-South Korean collaborators have successfully built their research on this foundation over the past decade.

Background

Ti and its alloys offer unrivaled properties for use in aircraft and spacecraft. Ti alloys are as strong as steel but are more than 40% lighter. Not only is their specific strength higher than that of aluminum (Al) alloys, but unlike Al, Ti alloys are not susceptible to exfoliation corrosion. If scientists substituted Ti for these other metals, most of the severe problems associated with aging aircraft would vanish or greatly decrease.



Common goals include eliminating defects, developing appropriate phases, and controlling the distributions of phases and grain orientations. In addition, scientists seek to reduce grain size, since metals become stronger as their grain size decreases. Collaborations between AFRL and South Korean academics have considerably supplemented these goals. AOARD is located in Tokyo, Japan, and works closely with AFRL on numerous basic and applied research projects. Collaborations between AFRL and South Korean researchers, especially in fundamental studies of metals and nanotechnology, have increased substantially over the past several years. In addition to metallurgy and nanotechnology, programs cover a broad range of topics, including advanced polymers, ceramics and composites, and human psychology.

Ceramic Matrix Composites Promise to Improve Turbine Engine Combustor Liners

Payoff

AFRL scientists worked with industry to make significant advancements in the manufacture and application of oxide-based ceramic matrix composite (CMC) materials for gas turbine engines. Hybrid CMCs offer numerous key advantages over conventional combustor liner materials, including greater toughness compared to monolithic ceramics, higher temperature capability compared to metal, less weight than metal components, inherent fatigue resistance, corrosion resistance in some applications, ability to manufacture complex composite shapes, thermal insulating characteristics, and potentially lower costs compared to complex metal shapes. These major improvements will benefit the Air Force, military aircraft engine development, and commercial aviation.

Accomplishment

AFRL researchers worked with the Siemens Westinghouse Power Corporation (SWPC); COI Ceramics, Inc. (COIC); Honeywell Engines, Systems, and Services; and Solar Turbines, Inc., to demonstrate the feasibility of using a promising combination of materials—hybrid oxide/oxide CMCs equipped with a new insulating material—to better safeguard inner and outer combustion chamber liners from the increasing heat loads associated with advanced performance gas turbine engines. The research and development effort clearly showed these materials work well and will help pave the way for increased power output, as well as reduced fuel costs, emissions, and associated cleanup costs. Hybrid CMCs that employ the SWPC-developed friable graded insulation (FGI) will also benefit commercial aerospace.

Background

AFRL funded Small Business Innovation Research (SBIR) Phase I and Phase II contracts with COIC to develop an oxide/oxide CMC capable of operating at 1200°C for over 100 hours. Both SBIR phases were successful. Concurrently, SWPC developed FGI, an advanced insulating material that consists of hollow alumina spheres. The FGI combines with the durable oxide/oxide CMC to form the hybrid inner and outer combustion chamber liners. SWPC, COIC, and Solar Turbines teamed to build and test a simple, can-shaped combustor for Solar Turbines' land-based power generator in California.

Additional research and development is necessary before hybrid CMCs can transfer to military aircraft and commercial aviation. Nevertheless, their environmental stability encourages continued development of oxide-based systems. Researchers will need greater experience in the processing and properties of these materials. Users will seek improved oxide-based CMCs to successfully undertake more severe, higher-payoff applications. Greater understanding and integration of designs will be essential to achieving the desired component performance. Current oxide/oxide CMCs can satisfy the requirements for some gas turbine engine applications, and scientists expect commercialization to follow.

Low-Plasticity Burnishing Enhances Turbine Engine Durability

Payoff

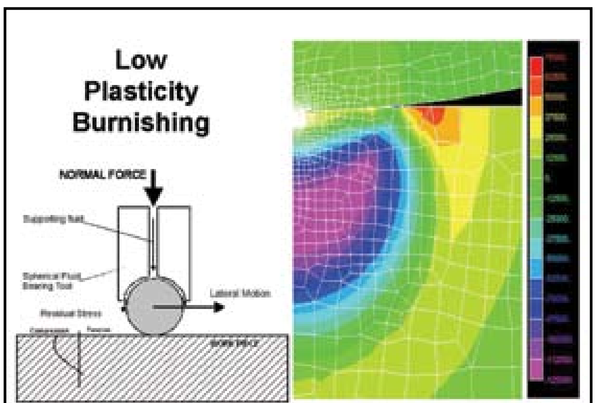
AFRL and Lambda Research, Inc., studied an innovative surface treatment technology to reduce turbine engine inspection costs and maintenance and extend engine components' operating life. The team conducted research under a Small Business Innovation Research (SBIR) contract and revealed that low-plasticity burnishing (LPB) can introduce deep, compressive residual stresses similar to those resulting from other advanced surface treatment processes, such as laser shock processing (LSP). LPB surface treatment provides an effective means to improve fatigue performance, particularly damage tolerance, in both new and legacy aircraft engines, ground-based turbines, and other fatigue-sensitive hardware. In addition to enhancing materials selection and design, the LPB treatment also offers the turbine designer a means to improve turbine engine component durability at lower costs.

Accomplishment

Under the SBIR project, AFRL, Lambda Research, the Naval Air Systems Command, and the National Aeronautics and Space Administration teamed to demonstrate the benefits of LPB surface treatment. The team confirmed that LPB provides a thermally stable layer of compressive residual stresses of comparable magnitude to—and even greater depth than—either shot peening or LSP. This result dramatically improves the fatigue performance of complex turbine engine hardware without altering either alloy or design. The studies also successfully demonstrated that users can perform LPB in conventional machine shop environments using computer numeric control (CNC) machine tools. The research effort also demonstrated that LPB can improve performance in numerous fatigue applications, including foreign object damage (FOD), stress corrosion cracking, fretting, welded joints, and biomedical implants.

Background

Many fatigue mechanisms, including high-cycle fatigue (HCF), FOD, corrosion fatigue, and fretting fatigue limit the life span of turbine engines, power systems, and aerospace structures. Until recently, HCF alone accounted for more than half of all major aircraft engine failures. Scientists demonstrated that deep compressive stresses, induced by LPB and other processes, can suppress many of these failure mechanisms.



LPB Processing Schematic and Associated FEM Simulation

The basic LPB tool consists of a ball supported in a spherical hydrostatic bearing. Any lathe or mill can hold the tool. The machine tool coolant pressurizes the bearing with a continuous flow of fluid to support the ball. The ball does not contact the bearing seat, even under load, and is loaded normal to the component's surface with a hydraulic cylinder in the tool's body. Users can perform LPB in conjunction with chip-forming machining operations in the same CNC machine tool. The ball rolls across the component's surface in a pattern defined in the CNC code, as in any machining operation. The treated hardware can be extremely complex. The pressure from the ball causes plastic deformation in the material surface under the ball. Since the bulk of the material constrains the deformed area, the deformed zone is left in compression after the ball passes. There is no material removal in the process, and the surface experiences inward displacement by only a few ten-thousandths of an inch. The design of the tool path and the normal applied pressure create a carefully engineered distribution of compressive residual stress, and the design of distribution counters applied stresses and optimizes fatigue performance.

Multiple SBIR Contracts Target JSF Engine Enhancement

Payoff

AFRL awarded five Small Business Innovation Research (SBIR) contracts to support emerging Joint Strike Fighter (JSF) engine technologies. Advanced engine designs for the F-35 JSF program pose many manufacturing challenges. The companies that received SBIR contracts are working with Pratt & Whitney and GE Rolls-Royce to enable advanced and affordable manufacture of advanced turbine engine components.

Accomplishment

AFRL awarded the Phase I SBIR contracts in an effort to enhance Pratt & Whitney F135 and GE Rolls-Royce F136 engines. Five separate companies (in conjunction with engine manufacturers) united under one program due to a combination of planning and funding opportunities, as well as AFRL's effective customer coordination.

Operating under AFRL oversight, the companies are conducting an array of research and development activities designed to enhance JSF engine technologies. Extrude Hone Corporation (Erwin, Pennsylvania) will demonstrate the ability to laser-drill cooling holes in thermal barrier coated turbine engine blades using a short-pulse laser technology known as SuperPulse™. Mikro Systems, Inc. (Charlottesville, Virginia), and FOPAT [Foam Pattern], LCC (Dayton, Ohio), are developing casting technologies to improve dimensional tolerances and cycle time. Mikro Systems will verify that manufacturers can use TML™ (tomolithographic-molding) to produce the ceramic strainers needed for investment casting, a technology that may be suitable for production of leachable ceramic cores. FOPAT will show the viability of a polymer process to manufacture patterns for investment castings to replace wax in the lost-wax process.

Maverick Corporation (Blue Ash, Ohio) and Adherent Technologies (Albuquerque, New Mexico) are developing organic matrix component technologies to reduce aircraft weight. Maverick Corporation will demonstrate the production of high-temperature resins in a continuous process versus the currently utilized batch process. Adherent Technologies will develop improved high-temperature power resin impregnated towpregs for use in the fabrication of high-quality tapes for automated placement processes.

Background

AFRL identifies various research and development topics each year as part of the Department of Defense (DoD) SBIR program. Topics represent a wide range of scientific and technical problems that the Air Force needs to address. The various DoD agencies publish these topics as solicitations each year, and in response, small businesses across the nation submit proposals. Phase I SBIR contracts usually grant $100,000 and run 6-9 months. Their design allows researchers to explore the technical merit or feasibility of an idea or technology. The AF SBIR program includes an important balance of topics reflecting AFRL's research mission.

AFRL Researchers Develop Integrated Oxygen Sensor for Aircraft Fuel Tanks

Payoff

AFRL researchers are developing a sensor that can measure the oxygen content of the vapor space above the fuel level (i.e., the ullage). This capability is critical for flight safety improvement and for controlling, monitoring, and maximizing the efficiency of a fuel tank inerting system, such as an Onboard Inert Gas Generation System (OBIGGS).

Accomplishment

Under a multicontract Small Business Innovation Research (SBIR) project, AFRL is working in conjunction with the Aeronautical Systems Center's (ASC) C-17 Systems Group to develop a sensor that can measure oxygen concentration of a fuel tank's vapor space. The Air Force supported multiple contracts for this effort due to the variety of technical approaches.

Throughout the Phase I SBIR contracts, an interdisciplinary team of government engineers from AFRL and the ASC C-17 Systems Group provided guidance for the technical efforts of TauTheta Instruments, LLC; InterSpace, Inc.; Aviation Safety Facilitators Corporation; and Physical Sciences, Inc. These experts worked together in all phases of the effort, providing input from different relevant viewpoints.

Three of the companies—TauTheta Instruments, InterSpace, and Physical Sciences—received Phase II SBIR contracts. Aviation Safety Facilitators Corporation is continuing its research in tandem with these follow-on efforts. A fifth company, Advanced Projects Research, Inc., completed its own Phase I SBIR project with the National Aeronautics and Space Administration and received a Congressional Aid contract for its continued efforts in the program. AFRL will administer this contract.

Background

Following the 1996 Trans World Airlines (TWA) Flight 800 tragedy, the Federal Aviation Administration's (FAA) associated investigations revealed that a combustible mixture in the center wing fuel tank ignited, creating enough pressure to cause the explosion. As a result of the TWA Flight 800 tragedy and other incidents, the FAA required a system for reducing the risk of explosions caused by fuel tank fires. One system, fuel tank inerting, dilutes ullage with an inert gas to render the ullage inflammable. OBIGGS allows an aircraft to maintain its fuel tanks in an inert status indefinitely.

OBIGGS pumps bleed air (from an aircraft engine) into air separation canisters. The air separation canisters filter the oxygen from the air, leaving a nitrogen-enriched mixture. The system then pumps this nitrogen-enriched mixture into the fuel tanks to dilute the ullage. Aircraft engineers can indirectly control the oxygen by knowing the tank ullage volume, temperature, and pressure, and then calculating the required nitrogen amount to dilute the ullage below the flammability threshold. When the engineers reduce the fuel tank oxygen level to 9%-12%, the ullage does not have adequate oxygen to ignite, even if there is a spark.

Although this type of development is immensely helpful, it is not a perfect system. Engineers still need a sensor to monitor the amount of oxygen in the tank. Engineers are concerned that the calculations may be flawed and are seeking a direct measurement technique that does not impose a hazard.

AFRL Technology Aids Aircraft Manufacturing Industry

Payoff

AFRL developed Air Force Growth (AFGROW) software, one of the fastest and most efficient structural crack life prediction tools available today. The Cessna Aircraft Company is just one of numerous companies from the aircraft manufacturing industry that are benefiting from AFGROW.

Accomplishment

The Cessna Aircraft Company used AFRL's AFGROW software to certify the damage tolerance of its new Citation Jet 3 (CJ3), verifying the aircraft met all requirements to earn Federal Aviation Administration certification. The CJ3 is the first aircraft that Cessna certified using AFGROW, and the company plans to use this software for all of its future projects.

Background

AFRL originally developed AFGROW to evaluate the reliability and risk of current Air Force platforms. AFGROW effectively predicts structural crack growth over time. It helps engineers determine service life for existing aircraft structures and creates preventative maintenance schedules. Additionally, engineers use AFGROW during the initial design process to help build structures that are more resistant to structural cracking.

AFGROW is a state-of-the-art, user-friendly computer program that can interface with Microsoft® (MS) applications. Users can cut and paste information between the MS Windows® clipboard and Windows-based applications such as Excel, compare experimental data points in the application to AFGROW's predictions, and then determine if the test model performed as expected. This capability eliminates the need for AFGROW users to create supplemental programs and thus saves time and money.

Over the last decade, AFRL has continually updated AFGROW with the latest analysis technology, and the software is available online free of charge. Many major aerospace companies—Cessna and Boeing, for example—use AFGROW, but scientists working in other industries can use the software for any structure that experiences fatigue cracking.

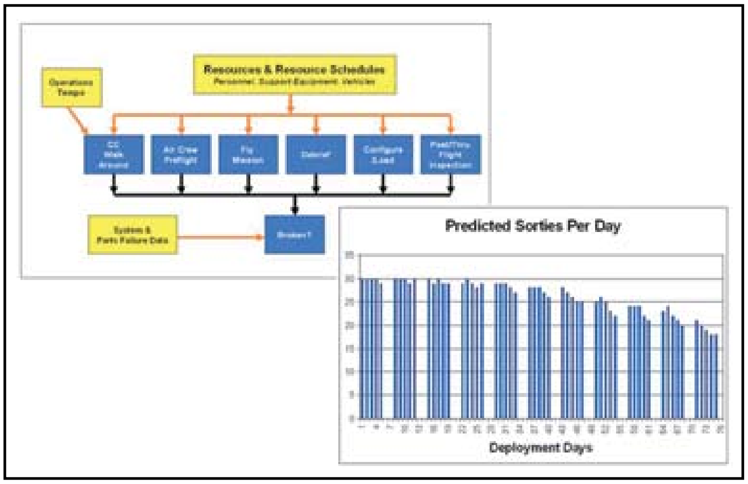
Simulation to Support Logistics Decision Makers

Payoff

AFRL sponsored the successful development of a desktop simulation tool that provides logisticians the capability to quantify impacts on the sortie generation process. A task that once required special expertise in systems simulation and laborious data collection can now be performed easily and accurately. Simulation enables logistics managers to conduct quick sensitivity analysis of their sortie generation capability and evaluate likely outcomes of different courses of action.

Accomplishment

The AFRL Small Business Innovation Research effort developed simulation solutions and earned several Air Force (AF) accolades. Scalable Integration Model for Objective Resource Capability Evaluations (SIMFORCE) models the resources necessary to support sortie generation. It calculates probable maintenance resource needs based on AF wing operational taskings. SIMFORCE also enables logisticians to quickly see the effects of reduced or increased resource levels on sortie capability.

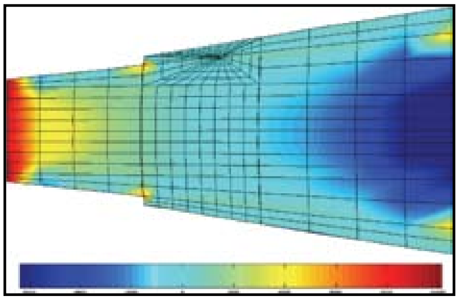


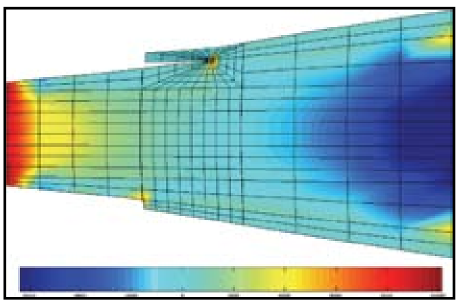
AFRL transitioned this technology to a major aircraft manufacturer that found the tool invaluable in evaluating new maintenance processes and capabilities proposed on several government contracts. The manufacturer also reported significant savings from this desktop simulation engine in exploring the effects of different logistical decisions.

Background

AFRL began researching the concept of an easy-to-use desktop simulation tool for modeling the sortie generation process in 1998. From this preliminary research, the laboratory developed multiple versions of SIMFORCE. One version included a Web-enabled tool that allowed remote access to the simulation capabilities. Recognizing the value of SIMFORCE, a funded expansion supported feasibility assessments in the Reusable Military Launch System program. Another organization used key elements of this tool in serial number tracking (SNT) and radio frequency (RF) military shipping labels (MSL). The SNT program reflects a Department of Defense-wide effort to establish a unique identification (UID) standard across all data systems. Through the use of SIMFORCE's simulation engine, the SNT program is investigating the impact of UID and SNT on the supply system. The RF MSL study explores implications of using data-rich RF tags as a standard MSL.

Enterprising Composite Design and Structural Analysis Tool Deployed to Rotorcraft Industrial Partner





Payoff

AFRL researchers and their on-site contractor, the University of Dayton Research Institute (UDRI), developed a unique composite material design and structural analysis tool to provide design solutions, reduce design cost, and improve operations safety for military, industrial, and commercial helicopters and other rotorcraft. The new, laboratory-developed design and analysis tool provides rapid solutions early in the design process to assess component damage tolerance and has the potential to trim component risk reduction costs and schedules by as much as 50%. The new technology also enables mission enhancement improvements in certification and supportability.

Accomplishment

The team's new tool provides a quicker and less expensive means to characterize and predict the behavior of flawed or damaged structures used to build the associated aircraft. Researchers coordinated with the United Technologies Research Center (UTRC) to develop the technology and transferred it to Sikorsky Aircraft Corporation. Scientists are adapting the new tool for rotorcraft applications throughout the Department of Defense (DoD).

AFRL scientists, assisted by UDRI, developed the unique composite material design and structural analysis tool based on an analysis code known as the B-spline analysis method (BSAM). BSAM uses a revolutionary numerical approach to model solid mechanics problems. The BSAM software consists of evolving computer code that analyzes the three-dimensional stress behavior within a layered composite material. The software performs general-purpose solid mechanics analysis based on an innovative method of assembling B-spline approximations of deformation in a numerical format to efficiently solve complex mechanics problems.

Researchers developed BSAM with technology transfer in mind. The US Government and aerospace industrial partners formed an alliance to guide the development of BSAM-related technology. In a coordinated effort with UTRC, AFRL developed the new BSAM-based design and analysis tool, ultimately delivering it to Sikorsky Aircraft Corporation.

Background

Composites are becoming the engineering material of choice for aerospace and high-performance applications. The BSAM-based tool has proven itself at least 8 times more efficient than state-of-the-art, finite element method codes for the analysis of composite materials with open holes. AFRL and UDRI researchers have primarily used BSAM as a research-oriented code to model various configurations ranging from bolted and bonded joints to fracture mechanics problems. They have also used it to test new theories on the deformation, strength, and durability of advanced composite materials, including the emerging complex fiber architectures envisioned by the aerospace industry. The successful delivery of the tool provides Sikorsky engineers a greatly enhanced ability to quickly design and evaluate key composite parts for future DoD and civilian rotorcraft.

Emerging Technologies

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Emerging Technologies

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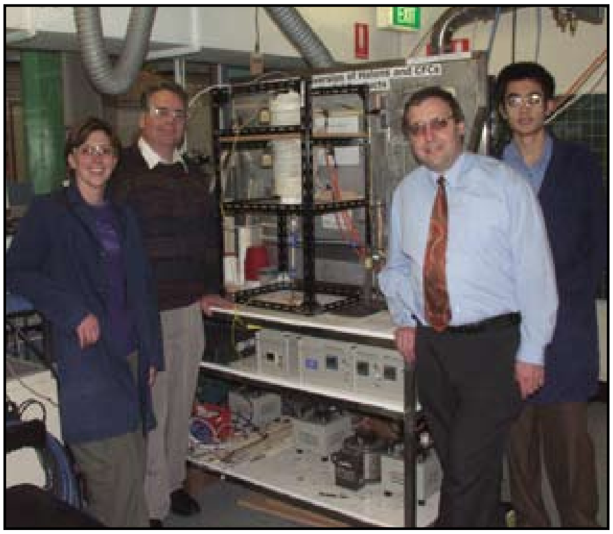
Conversion of Ozone-Depleting Substances

Payoff

AFRL managed research to economically convert two ozone-depleting substances, Halon 1211 and 1301, to difluoroethylene, an industrially useful chemical feedstock. Professor Eric Kennedy and fellow researchers at Australia's University of Newcastle discovered a way to convert halons into the useful substance. Once used by firefighters, halons are thermodynamically stable but relatively unreactive chemicals. Halon 1211 is used in small, portable fire extinguishers, while Halon 1301 serves as a gaseous agent in total room fixed-flooding systems.

Accomplishment

AFRL's Tokyo Detachment tasked the researchers to improve upon the cost-prohibitive incineration method of destroying the halons. In order to create the chemical reaction that produces difluoroethylene, Professor Kennedy's team used a laboratory-scale reactor capable of processing 3000 kg of halon per day to react with methane. The research team determined that a plant capable of processing 900 metric tons of halon per year would realize an annual profit of more than $1.3 million in Australian currency.



Halons were banned in 1987 because of their harmful effects on the ozone layer. The team was able to convert this hazardous product into a useful substance. This research benefits the Air Force because it still possesses large quantities of halon in firefighting equipment purchased before the ban.

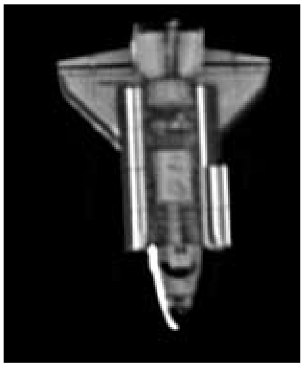
Background

Difluoroethylene is the feedstock used to produce polyvinylidene fluoride, commercially known as Viton®—a high-performance elastomer used in the aerospace, automotive, fluid power, appliance, and chemical industries. Viton products include abrasion- and chemical-resistant coatings for metals and other materials, high-performance gaskets and seals, and chemical-resistant hosing.

AFRL-Sponsored Astronomy Professor Developing Advanced Imaging Algorithms

Payoff

AFRL funded Dr. Stuart Jefferies to develop advanced imaging algorithms for the creation of sharper images. Dr. Jefferies is devising a method to arm tankers and pilots with imaging capabilities that will allow them to distinguish allies from adversaries regardless of the conditions. These algorithms will permit the military to identify satellites more accurately and to identify objects such as planes in cloudy conditions.

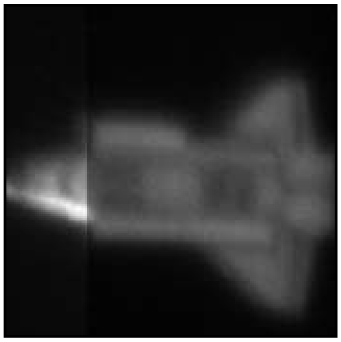


Accomplishment

Dr. Jefferies is a physics and astronomy professor at the University of New Mexico's Maui Scientific Research Center (Maui, Hawaii). In his quest to advance ground-based space surveillance and space situational awareness (SSA), Dr. Jefferies developed an image restoration algorithm that employs a "more is better" approach. Image quality improves with the use of adaptive optics, such as a flexible mirror placed behind the telescope to decrease the distortion. Dr. Jefferies is developing image restoration algorithms both to make images sharper and to process data.

Background

In addition to the development of image restoration algorithms, Dr. Jefferies and his colleagues are developing several techniques to advance SSA, including adaptive pupil masking and tomographic laser guidestar methods to improve the wave-front sensing required for accurate adaptive optics correction. The field of medical imaging, specifically noninvasive breast exams, may also benefit from Dr. Jefferies' research.



AFRL-Funded Research Team Discovers Super Atoms

Payoff

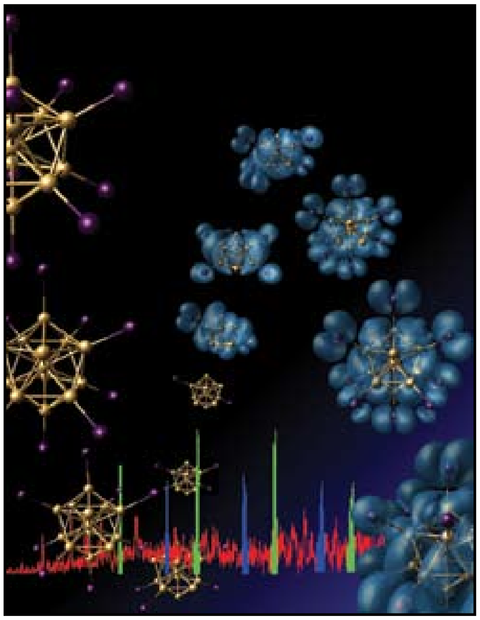
An AFRL-funded research team discovered aluminum (Al) atom clusters that, when reacted with iodine, exhibit chemical properties similar to those of the single atoms of metallic and nonmetallic elements. The discovery of the new iodine compounds reveals the potential for a "super atom" chemistry based on a new periodic table of cluster elements. Scientists can apply this enhanced chemistry to create unique compounds with distinctive new properties, ultimately increasing spacelift capability and significantly reducing the weight and size of many conventional weapons. Dr. Shiv Khanna and colleagues at Virginia Commonwealth University made the significant discovery, which could eventually lead to major breakthroughs in medical, energy, photographic, and food production applications.

Accomplishment

For nearly 2 years, Dr. Khanna and Penn State University chemist Dr. A. Wellford Castleman, Jr., worked to alter atom clusters of one element—Al—without changing its number of protons and electrons. Their goal was to induce a cluster to behave the same way that a single atom of another element behaves. The team's research targeted Al based on its abundance in the earth's crust and its innumerable uses. The metal is also extremely reactive and corrosion-resistant.

Background

The research team substituted a cluster of 13 Al atoms (Al13) for iodine atoms in naturally occurring chains of iodine atoms and in molecules known as polyiodides. When the researchers replaced the iodine atom with the Al13 cluster, the entire chemistry of the compound changed, causing the other iodine molecules to break apart and bind individually to the Al cluster. They were able to bind as many as 12 iodine atoms to a single Al13 cluster, thereby forming a completely new class of polyiodides with the characteristics of a single iodine atom. When an even number of iodine atoms bind to the Al cluster, the resulting super atom is very stable and does not react with other elements—not even oxygen. If the number of iodine atoms is odd, the super atom is unstable and reactive.



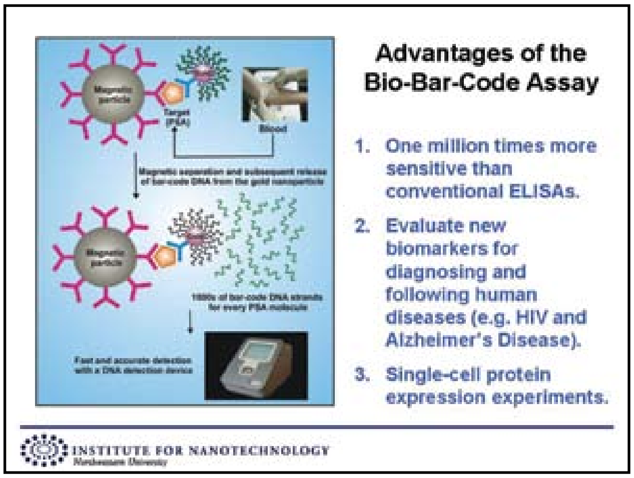
The Al13 cluster's capacity to mimic a single iodine atom's behavior demonstrates that super atoms can have synthetic utility, providing an unexplored third dimension to the traditional periodic table of elements. Applications using Al13 clusters instead of iodine atoms in polymers may lead to the development of improved conducting materials. Dr. Khanna believes that Al13 clusters may provide Al materials that will not oxidize, helping to overcome a major problem in fuels that burn Al particles. The team also substituted an Al14 cluster for the iodine atom, resulting in a super atom that behaves like alkaline earth metals, such as beryllium, magnesium, barium, radium, and strontium. Dr. Khanna's team intends to expand its work to create super atoms using metals other than Al.

Groundbreaking Research in Nanotechnology

Payoff

AFRL is funding Dr. Chad Mirkin, director of Northwestern University's Institute for Nanotechnology, to conduct bionanotechnology research. His groundbreaking bionanotechnology research could lead to the development of detection systems for identifying markers associated with biological warfare agents. In addition, his nanoparticle research could enable early detection of diseases such as human immunodeficiency virus (HIV), cancer, bovine spongiform encephalopathy (mad cow disease), and Alzheimer's.

Accomplishment



Dr. Mirkin developed tests that are a million times more sensitive than current disease detection methods. His research focuses on the development of methods to control the architecture of molecules and materials ranging from 1 to 100 nm in length. He uses these structures to develop analytical tools for use in chemical and biological sensing, lithography, catalysis, and optics.

Dr. Mirkin's tests are designed to identify specific proteins present in blood and body fluids when diseases occur. The quantity of these disease markers is often too low to detect using conventional diagnostic methods, which may therefore fail to detect such markers until a disease is in its advanced stages. His tests can detect even a small number of proteins in a single drop of blood. The tests employ two types of nanoparticles: magnetic nanoparticles and nanoparticles covered in short strands of deoxyribonucleic acid (DNA). Both types have antibodies that can recognize a disease target. When mixed into a blood sample, the nanoparticles, which measure 30 nm, adhere to the ends of existing disease proteins.

Scientists use a magnetic field to pull the magnetized nanoparticles from the blood, extracting the disease proteins and DNA-covered particles with them. They then release and detect the DNA by means of Dr. Mirkin's chip-based technology. For every protein that a nanoparticle captures, hundreds of DNA strands are released, providing a built-in form of signal amplification.

Background

Dr. Mirkin, in collaboration with neuroscientist Dr. William Klein, used the tests to identify cerebral spinal fluid proteins that are linked to Alzheimer's disease. Today's researchers can confirm Alzheimer's only by postmortem examination. Dr. Mirkin also demonstrated that the tests can detect HIV markers in blood. Early detection of low HIV levels could vastly improve patient care and lead to a safer national blood supply. Today's tests cannot identify HIV proteins until approximately 3 months after infection.

Dr. Mirkin is a 2004 National Institutes of Health Director's Pioneer Award winner and a three-time recipient of the National Inventors Hall of Fame Collegiate Inventor award. He has also pioneered the use of biomolecules as synthons in materials science and the development of nanoparticle-based biodiagnostics. Many concepts and materials developed within his laboratories have established the basis for commercial detection and lithography systems.

AFRL-Sponsored Researchers Develop Enhanced Digital Imaging

Payoff

AFRL sponsored Dr. James Nagy and researchers at Emory University's School of Mathematics and Computer Science to develop methods to enhance digital images for diverse applications ranging from astronomy to crowd surveillance. Dr. Nagy's team is developing computer-based image enhancement techniques, or algorithms. AFRL also sponsored Dr. David Tyler, a research professor at the University of Arizona Optical Sciences Center who works with Dr. Nagy and others to develop advanced image enhancement algorithms.

Accomplishment

Dr. Tyler frequently visits Maui, Hawaii, the site of AFRL's Maui Space Surveillance Site (MSSS) and Maui High-Performance Computing Center (MHPCC), as well as the University of New Mexico's Maui Scientific Research Center (MSRC). At these facilities, he works with colleagues to develop, test, and exploit advanced imaging algorithms for space surveillance. AFRL asked the MSRC and two members of Dr. Tyler's group to use one of their design-phase algorithms to enhance images of the Space Shuttle *Columbia*. An MHPCC telescope captured these images on the *Columbia's* final voyage. Dr. Tyler and other collaborators produced images of the Space Shuttle *Discovery* after it was damaged on launch. They used the MSSS telescopes to generate images of *Discovery*, which carried Senator John Glenn (retired). Astronomy will benefit from these image enhancement advances, and the research could revolutionize video surveillance applications as well.

Background

Dr. Nagy emphasizes that his team focuses on improving computer-based image enhancement techniques; they are not concerned with improving cameras. Mathematicians refer to this field of study as inverse problem solving. Inverse problem solving is more than 100 years old, but only recently have the capabilities of high-performance computers and powerful imaging devices merged to allow theories to transfer from hypothetical to real-world applications in physics, chemistry, biology, and medicine. Dr. Tyler insists the technique's long germination period has not prevented physicists, chemists, biologists, and doctors from quickly embracing the technology.

The Study of Fruit Flies Benefits the Design of Biomimetic Flying Devices

Payoff

Dr. Michael Dickinson, an AFRL-funded bioengineer at the California Institute of Technology, and his colleagues are studying the muscle control of fruit flies during precision flight. Dr. Dickinson predicts that their research results will lead to the production of flying robots that can perform surveillance operations. These results will also benefit future military operations and provide insight into the design of biomimetic flying devices.

Accomplishment

Until recently, scientists did not know how flies remained airborne. The conventional laws of aerodynamics dictate that a fly's tiny wings are too small to support its body weight. Furthermore, scientists had long assumed that the air viscosity—not inertia—was the insect's greater obstacle. Dr. Dickinson and his team proved that fruit flies make subtle changes in their wing tilt (relative to the ground) and the size of each wing flap to generate the forces that allow them to turn. Flies then create an opposite twisting force with their wings to stop the inertia of the turn, preventing an uncontrollable spin.

The team used an infrared, three-dimensional (3-D), high-speed video camera to observe the fruit flies in an enclosed arena. The team captured the fruit flies' maneuvers during rapid 90° turns. The camera captured images of these swift turns, permitting a 3-D analysis of the flies' wing and body positions during the turns. Dr. Dickinson and his team concluded that fruit flies perform banked turns in a manner similar to larger flies, who must overcome inertia rather than friction.

Dr. Dickinson built a huge model of the fruit fly's wings to better understand the aerodynamic forces generated by these flies. The contraption mimics the atmospheric effects of a fruit fly's 1-millimeter-long wings in flight. His team also constructed a 15 in. robotic wing that flaps and rotates in a 2-ton tank of mineral oil at one-hundredth of a fly's wing speed. A computer determines the precise motions of the robotic wing, which is powered by three motors. Bubbles pumped into the tank display the aerodynamic patterns; sensors measure the forces on the wings during each phase of the stroke.

Background

Fruit flies make high-speed 90° turns, make upside-down takeoffs and landings, and even carry twice their body weight. Dr. Dickinson concluded that a fruit fly generates torque to accelerate into the turn. The fly then has to actively counteract the inertia of the turn by producing torque in the opposite direction, bringing the body rotation to a halt. Although these experiments targeted tiny fruit flies, Dr. Dickinson insists the results apply to nearly all insects, because the importance of inertia over friction increases with the insect's size.

AFRL Develops Palm-Sized Device for Imaging and Scanning

Payoff

Dr. James Kolodzey, an AFRL-funded professor of electrical and computer engineering at the University of Delaware, and his research team used the power of terahertz (THz) frequencies to develop a portable apparatus. The team harnessed its THz system in a palm-sized device to advance X-ray technology and the early detection of cancer.

Accomplishment

Dr. Kolodzey led his team's efforts to design a device based on a silicon germanium semiconductor, which scientists use to choose energy bands that relate to THz frequencies. The device is similar to a laser pointer; the researchers use filters to fine-tune the frequency and employ a waveguide to gather and broadcast the signal.

AFRL can apply the portable THz technology to imaging and scanning due to the technology's sensitivity to molecules and ability to travel through solid material. The technology is similar to X-rays, and scientists believe it is safe; therefore, it may complement an X-ray machine such as in a dentist's office. The THz system is ideal for environmental or emergency situations, such as identifying hazardous materials or locating someone buried under heavy rubble. Scientists can use the device in the early detection of cancer cells due to the cells' vibrant THz signature.

Background

Acknowledged as the final frontier in the study of electromagnetic waves, THz frequencies are located between microwaves and infrared frequencies. THz frequencies are 100 to 1,000 times lower in frequency than visible light and 1,000 times higher than microwaves. The new palm-sized device is more accessible than the original THz systems, which exist in room-sized pieces of machinery.

UAV Automated Aerial Refueling One Step Closer to Reality

Payoff

AFRL successfully completed a flight demonstration to evaluate the feasibility of using precision Global Positioning System (GPS) and electro-optical (EO) technology for unmanned air vehicle (UAV) automated aerial refueling (AAR) applications. UAVs capable of refueling in the air will have the persistence to stay on station for extended periods of time and the ability to join the flight from bases thousands of miles away.

Accomplishment

During the flight tests, a Learjet 25, from General Dynamics, served as a surrogate UAV for simulated aerial refueling from a KC-135 Stratotanker, from the New York Air National Guard's 107th Air Refueling Wing.

AFRL scientists successfully collected quality data from the GPS and the EO sensor. They are using these test results to determine safe refueling speeds, possible tanker interference with GPS reception, and the effectiveness of using EO sensors for precise UAV positioning during AAR. In addition, they will use the data to create a flight control algorithm that will autonomously fly the surrogate UAV in the future.

Background

AAR is a challenging task, balancing performance with reliability and safety. For AAR to be possible, the GPS or EO sensors must provide position control within inches of accuracy. The Naval Air Systems Command, the Air Force Flight Test Center, General Dynamics, Rockwell-Collins, Boeing, the New York Air National Guard's 107th Air Refueling Wing, and Northrop Grumman all made valuable contributions to this AFRL-led effort.

AFRL Successfully Demonstrates Joined-Wing Technology

Payoff

The joined wing provides a long-endurance, high-performance platform capable of supporting a next-generation sensor suite to perform Air Force intelligence, surveillance, and reconnaissance (ISR) missions. The joined-wing vehicle configuration is a high-altitude and long-endurance concept that provides natural 360° radar coverage with conformal load-bearing radar systems embedded in a multifunctional structural technology wing structure.

Accomplishment

AFRL successfully completed the first flight test of a 7% scale, joined-wing technology demonstrator. During the test, a small unmanned air vehicle with joined wings completed several takeoffs and landings that culminated with a 2-minute run in which the vehicle took off, circled, and then landed in the spot where it took off. Engineers will use the flight test data to incrementally improve the scaled vehicle's design. Ultimately, AFRL envisions a new, aeroelastically scaled research vehicle as a way to explore gust load alleviation devices and, consequently, structural weight reduction.

Background

The joined-wing vehicle concept has two wings on the fuselage that sweep back to meet two forward-swept wings originating from the tail area. Viewed from above, the wings form a diamond shape. Joined wings would be ideal for the SensorCraft concept; their shape would allow powerful 360° radar to be incorporated into the SensorCraft's wings. Not only would this antenna placement free space on the vehicle's body for other equipment, it would also give the radar a virtually unobstructed view of the surrounding environment.

AFRL is developing the SensorCraft concept as a tool to investigate how emerging technology for sensors, communications links, air vehicle components, and propulsion systems could be incorporated to create the next-generation ISR vehicle. The SensorCraft will help engineers determine the joined-wing vehicle's viability.

AFRL Demonstrates Upper Surface Blowing Concept

Payoff

Powered lift technology may one day increase the speed range at which large air vehicles, such as tanker or transport aircraft, can fly. Powered lift could enable these air vehicles to fly at speeds just above a hover, without interfering with maximum speed. In addition, it may decrease the ground footprint required for takeoff and landing.

Accomplishment

AFRL scientists worked with Compositex, Inc., as part of a Small Business Innovation Research effort to prove the upper surface blowing (USB) concept as one method to achieve powered lift. Engineers successfully demonstrated USB during the flight test of a small unmanned air vehicle (UAV) that weighed approximately 6 lbs. Not only did the demonstration's success prove the possibility of using USB technology, it also opened up possibilities for using the same type of small UAV to demonstrate future air vehicle concepts.

Background

In this version of USB, airflow generated by a ducted fan channels into a plenum inside the wing instead of exhausting through a conventional nozzle. The flow then exits the plenum through a narrow, aft-facing blowing slot that runs along the wingspan on the upper side of the wing just aft of the leading edge. The resulting jet entrains air over the wing's upper surface, similar to the "ejector" concept. It also acts like a "jet flap," thus increasing both thrust and lift. This increase should enable very-low-speed flight as well as short takeoff and landing operations.

Engineers have examined powered lift since the 1950s; however, they have had little success putting the theory into practice. One obstacle to successful implementation has been weight and efficiency penalties due to the plumbing. Another obstacle, low-speed performance, often comes with a severe cruise drag penalty. The current effort targets risk reduction by demonstrating the concept in a small UAV, where design changes can be made inexpensively and rapidly.

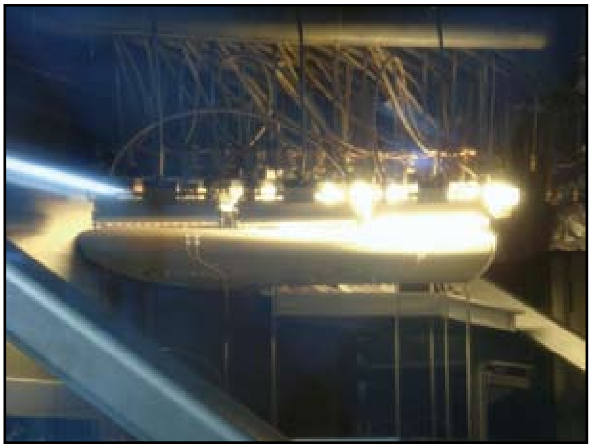
AFRL Supports NASA X-37 Program

Payoff

AFRL provided state-of-the-art support to the National Aeronautics and Space Administration (NASA) using the laboratory's unique, in-house experimental validation capabilities. This partnership enables development of future reusable launch vehicle technology.

Accomplishment

AFRL completed vital experimental validations on a carbon-carbon ruddervator control surface subcomponent that may one day be used on the X-37 reusable launch vehicle. During a series of thermal and static load tests, the ruddervator subcomponent successfully withstood temperatures up to 2300°F and static loads 2 times higher than those of operational conditions. NASA used these test results to verify the ruddervator's analytical model. Subjecting the ruddervator to such extreme conditions was an important part of verifying that it could resist exposure to the conditions experienced during orbit reentry.



Background

These tests supported NASA's current evaluation of possible control surface designs for its X-37 orbital vehicle concept. These control surfaces include ruddervators, which control pitch and yaw, and flaperons, which control roll and augment lift. The tests' nature and volume prompted NASA to seek AFRL's help in sharing the work. Boeing provided NASA the test article, which was designed by Science Applications International Corporation and manufactured by Carbon-Carbon Advanced Technologies.

AFRL's Aerospace Structures Research Facility is the largest combined-environment experimental facility in the world. It provides state-of-the-art validation capabilities to all government agencies and to industry and academia through Cooperative Research and Development Agreements. In addition to the thermal and mechanical load validation capabilities it provided for these experiments, the facility can simultaneously expose structures to mechanical loads, acoustic noise, vibration, and heat to simulate conditions experienced by air and space vehicles during flight. Scientists use this resource to solve various air vehicle structural problems and ultimately increase aircraft performance.

AFRL Demonstrates Advanced Simulation Capability

Payoff

AFRL is testing new directed energy weapon (DEW) technology in a virtual computer simulation environment. Scientists are testing the DEW technology without the expense or safety precautions that result from building the weapon and testing it in a real-life situation. Computer simulation eliminates the need to build the weapon and incorporate it into an existing airframe; therefore, AFRL can greatly reduce expenses and eliminate danger that might result from working with powerful lasers in the real world.

Accomplishment

AFRL demonstrated a computer model of a DEW-equipped tactical aircraft operating in a simulation environment. The laboratory's Tactical High-Energy Laser Utility Study team integrated the DEW model into a simulation environment and evaluated the DEW's ability to destroy incoming threats. Engineers created the DEW model using technology and documentation supplied by AFRL and other government and nongovernment sources.

Background

AFRL's simulation environment comprises an advanced suite of simulation tools that simulate a real-time, virtual environment. AFRL plans to evolve the simulation so that pilots can interact and manually target threats. Eventually, pilots will manually fly in a simulated engagement of two aircraft against four aircraft.

After conducting an initial engagement utilizing only conventional weapons, engineers will conduct a final combat simulation in which the two-aircraft team will be outfitted with DEWs, and the four-aircraft team will retain its conventional weapons. This engagement will better assess the DEW's performance against conventionally equipped aircraft.

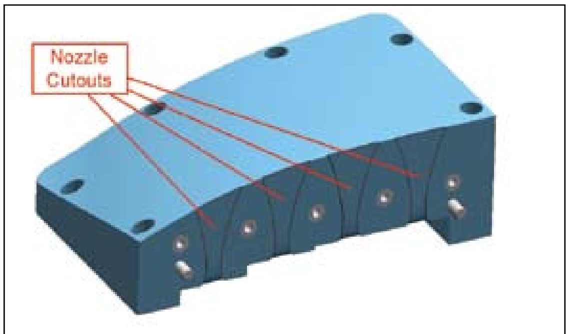
AFRL is working to improve the simulation, developing new display and control mechanisms to help pilots use the DEW to target threats, while developing power and thermal management subsystems for the aircraft model.

AFRL Performs Successful J-UCAS Acoustic Suppression Wind Tunnel Tests

Payoff

AFRL scientists teamed with Boeing Aerospace to develop supersonic flow control actuators as a replacement for the spoilers traditionally used to reduce weapons bay acoustics. The actuators, powered by engine bleed air, effectively reduce acoustics over a wide range of flight conditions, aid in safe weapons separation, and do not protrude from the aircraft.

Accomplishment



Computer-Aided Design image of the supersonic nozzle flow control device. A flat plate completes the nozzle walls and acts as the forward bulkhead of the weapons bay.

AFRL scientists developed flow control actuators that operate on available engine bleed air and expel a supersonic jet of air that counters the acoustic resonance created by opening weapons bay doors during flight. The actuators can be used for both suppressing acoustic resonance and enhancing weapons release.

In a series of wind tunnel tests conducted at Arnold Engineering and Development Center, Arnold Air Force Base (Tennessee), AFRL scientists coordinated with the Joint Unmanned Combat Air Systems (J-UCAS) System Program Office to determine the effectiveness of these actuators. Using the J-UCAS weapons integration model, AFRL scientists proved that the actuators effectively reduced the acoustic resonance created by opening weapons bay doors. In addition, they determined that the actuators improved the position and attitude of a model MK-83 Joint Direct Attack Munition upon its release from the model's weapons bay.

Background

Opening weapons bay doors during flight creates a shear layer—an area where airflow transitions sharply from the high-speed airflow outside the weapons bay to slower-speed airflow within the bay. The result is flow instability; pockets of circularly rotating air, called vortices, hit the weapons bay walls and generate an acoustic wave. This wave flows back up the airstream and causes acoustic resonance, producing strong vibrations that may damage the aircraft and its systems.

Flow control devices are designed to counter this effect. The J-UCAS program is a joint Defense Advanced Research Projects Agency/Air Force/Navy effort to develop an unmanned air vehicle to carry out missions in areas such as surveillance, precision strike, and enemy air defense suppression.

AFRL Improves Planning and Investment Decisions With Quantitative Technology Assessment

Payoff

AFRL completed a 2-year effort to create the quantitative technology assessment (QTA) process, which incorporates new methodologies and tools with existing industry-standard tools to effectively evaluate the effects of new technologies on air vehicle capability. QTA measures the impacts of implementing air vehicle technology in less time and with higher fidelity than previous methods. The result is an improvement in program managers' abilities to make planning and investment decisions.

Accomplishment

To demonstrate QTA, AFRL scientists evaluated different technology sets with the aim of improving mission performance of the SensorCraft, a high-altitude, long-endurance air vehicle concept. Improving laminar flow (i.e., smooth airflow over the surface of an air vehicle) was one of the technology sets that the scientists investigated. They used the QTA process to combine detailed geometry, computational fluid dynamics, finite element modeling, and traditional vehicle-level mission analysis to create a high-fidelity model of a SensorCraft mission. They used this model to examine how the incorporation of several different technology sets affected the vehicle's performance. Then they transformed raw data from this analysis into meaningful information that enabled decision makers to understand the technology and determine the best options.

This demonstration proved QTA's superiority over previous methods in four main areas: (1) QTA's automation and modeling greatly reduced analytical cycle time, which allowed analysis of thousands of cases in the same amount of time previously required for 100 cases; (2) QTA's combination of individual disciplinary models for investigating multiple problem aspects increased process fidelity; (3) QTA's reduced time and improved process fidelity enabled broader design space exploration that required half the people and time; and (4) QTA's analytical framework enabled real-time interaction between models from geographically separate organizations.

Background

Better responsiveness to the warfighter's needs and today's changing world threats requires the rapid evaluation of new air vehicle technology. QTA quickly and accurately provides decision makers the information they need to determine which technologies have the most potential benefit.

AFRL Completes Full-Scale Flight Demonstration of Active Aeroelastic Wing Technology

Payoff

AFRL's active aeroelastic wing (AAW) technology improves performance and decreases aircraft weight 5% to 20%, benefiting future aircraft designs such as unmanned air vehicles, advanced transports, and advanced fighter concepts. For high-altitude, long-endurance air vehicles, AAW technology alleviates gust loads and manages wing warping, increasing aerodynamic efficiency. In fighter aircraft, AAW technology improves vehicle maneuver rates and reduces structural loads and overall aircraft drag. AAW is an enabling technology for tailless air vehicles capable of high performance during transonic and supersonic flight.

Accomplishment

AFRL teamed with the National Aeronautics and Space Administration's Dryden Flight Research Center and Boeing to complete flight testing of an F/A-18 research aircraft modified with AAW technology. Engineers evaluated control laws designed to exploit wing aeroelastic twist as the F/A-18 completed a series of roll, rolling pullout, and windup turn maneuvers in 18 different Mach/altitude combinations. This demonstration proved that the exploitation of wing aeroelastic twist can significantly improve vehicle performance by dramatically improving vehicle roll rate and reducing wing structural loads.

Background

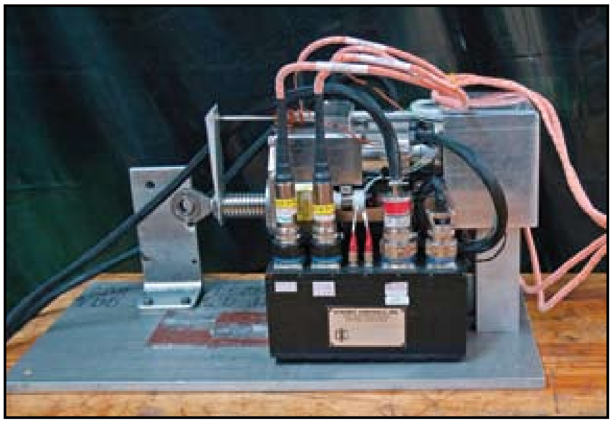
AAW technology takes advantage of high-speed aircraft wings' tendency to aeroelastically warp or twist at very high speeds, which often negatively affects aircraft performance. AAW enables thinner, higher-aspect-ratio wings, which can greatly reduce air vehicle weight and improve performance.

The AAW concept traces back to the Wright brothers, who did not use control surfaces such as ailerons or flaps on their airplane. Instead, they controlled rolling motion by twisting or warping the wingtips with a sling in which the pilot lay. By moving his hips from side to side, the pilot warped the wings, providing the necessary flight control for the aircraft.

AFRL Develops Fly-by-Light Technology

Payoff

AFRL is developing fly-by-light technology flight control systems to be lighter and smaller, require less maintenance, and be more resistant to electromagnetic impulses than conventional fly-by-wire systems. AFRL's fly-by-light technology does not employ wires and is naturally resistant to electromagnetic interference (EMI), providing the same flight control capabilities as fly-by-wire systems without the necessity for shielding.



Accomplishment

AFRL teamed with Northrop Grumman; BAE Systems; and Dynamic Controls, Inc., to validate a fly-by-light, photonic-controlled actuation system (PCAS). The PCAS consists of a modified electromechanical actuator (EMA) and an optical controller that provides actuator commands to the optical EMA. These commands are similar to the commands that a flight control computer provides. Engineers modified the EMA's motor power devices to receive and react to command signals sent via light from the optical controller. In addition, they replaced the EMA's conventional sensors with optical sensors that measure actuator position, motor position, and current. Fiber-optic cables transmit information to the optical controller. Engineers collected EMA performance data during a series of test runs. Data analysis verified that the modified PCAS performed as designed, with no adverse effects to performance stemming from the fly-by-light components or technology.

Background

The EMA consists of two small electric motors, a gear train transmission, and an actuator ram (ball screw) that moves to operate an air vehicle flight control surface, such as an aileron. Conventional EMAs are just one part of an air vehicle's fly-by-wire flight control system, which supplements the pilot's control over the aircraft's control surfaces. Fly-by-wire systems use a closed-loop feedback system that can correct air vehicle instabilities many times faster than the pilot. It enables engineers to develop airframes capable of maintaining safe aircraft operations while meeting extreme mission needs such as low observability, high maneuverability, and long endurance.

Fly-by-wire system vulnerability to EMI is a concern, since EMI is present everywhere in the atmosphere (e.g., radar, radio signals, and lightning). These signals can couple onto the wires and circuits of unshielded electronic devices and cause erroneous signals that can disrupt the system. Currently, shielding protects fly-by-wire systems against EMI, and while shielding is effective, it adds weight, volume, expense, and timely maintenance requirements.

AFRL Demonstrates Airborne Active Flow Control System

Payoff

Active flow control technology has the potential to reduce air vehicle weight, complexity, and radar signature and eliminate the need for air vehicle control surfaces. In addition, this technology promises to reduce buffeting of external aircraft stores while the aircraft travels at transonic speeds, thus eliminating the operational restrictions incurred from integrating stores (e.g., weapons) onto aircraft.

Accomplishment

AFRL recently demonstrated the first airborne active flow control system to reduce turbulent airflow in the wake of an external pod, which experts mounted on an aircraft. For this demonstration, engineers outfitted an F-16 aircraft with a Low-Altitude Navigation and Targeting Infrared for Night (LANTIRN) system pod. Scientists augmented the LANTIRN system pod with several small, electrically controlled piezoelectric synthetic jet (PESJ) actuators.

These actuators received the air that flowed over the pod surface and ejected the air to significantly affect the dynamic pressure of the pod's wake. Each PESJ actuator measured approximately 1/2 in. thick with a 3 in. diameter. Despite the PESJ actuators' size, just 6 units produced dramatic results.

This demonstration was possible through AFRL's collaboration with the US Air Force Test Pilot School, the Air Force Institute of Technology, General Electric, and Lockheed Martin. The team developed an airborne wind tunnel system that allowed evaluation of this active control system in the real world as opposed to the traditional wind tunnel environment.

Background

Part of an AFRL multiphase research program, this effort's next phases will focus on the integration of piezoelectric vibration suppression actuators into the F-16 ventral fin, the evaluation of additional flow control actuator concepts, and the development of synergistic design concepts leveraging both flow and structural control systems to optimize system performance.

Buffeting occurs when high-performance aircraft operate at high speeds. During these conditions, vortices emanate from the leading edge of aircraft structures and create turbulent flows and dynamic loads that vibrate the structure. Prolonged buffeting can cause fatigue damage that restricts aircraft capability and availability.

AFRL Demonstrates SensorCraft Wing Model

Payoff

Future intelligence, surveillance, and reconnaissance (ISR) platforms, such as the SensorCraft, require thinner, higher-aspect-ratio wings for reduced air vehicle weight, improved performance, and increased ability to remain on station for longer periods of time.

Accomplishment

AFRL, Northrop Grumman, and the National Aeronautics and Space Administration (NASA) teamed on the High-Lift-Over-Drag Active (HiLDA) Wing program to successfully demonstrate a 12% scaled model of a highly elastic SensorCraft concept wing. During a series of wind tunnel tests at NASA's Transonic Dynamics Tunnel, scientists subjected this wing to events characteristic of a steady, smooth flight environment, as well as events (e.g., erratic wind gusts) more typical of extreme conditions. These tests allowed AFRL engineers to reduce the structural loads caused by gusts by a factor of 2.

During the steady flight conditions, scientists successfully reduced the wing's drag by making slow, deliberate adjustments to the wing's control surfaces to maximize its lift-to-drag ratio. During the gusty conditions, scientists successfully alleviated the wing's structural loads by continuously making small adjustments to the control surfaces. In the future, this ability to make the adjustments that enable a much lighter wing structure to endure strong wind gusts will increase the SensorCraft's capabilities and enable it to remain on station longer.

Background

AFRL is developing air vehicle technologies and vehicle concepts to enable a future ISR capability. In support of the SensorCraft concept, the HiLDA Wing program evaluated active wing technologies, including active flow control, adaptive structure, and active aeroelastic wing technologies. During this specific effort, scientists studied the response of a highly flexible SensorCraft wing to steady and unsteady aerodynamic loads.

AFRL Builds Portable Laser Weapon

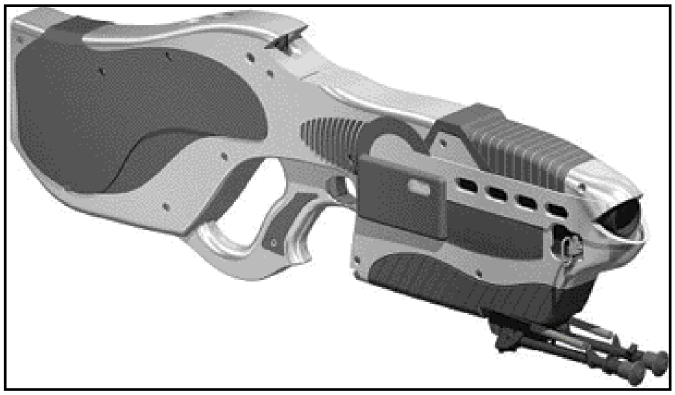
Payoff

AFRL's Personnel Halting and Stimulation Response (PHaSR) is the first man-portable laser weapon of its kind. The device uses high-efficiency semiconductor lasers and innovative thermal management to produce a two-wavelength laser system capable of fielded deployment for force protection, crowd control, and access denial. PHaSR is a truly revolutionary weapons system that introduces a new wave of handheld, single-operator laser systems for point and perimeter defense functions.

PHaSR operates multiple integrated lasers from a man-portable platform. The system will function optimally in a nonlethal force protection or crowd control application. PHaSR will also operate as a nonlethal deterrent against hostile or potentially hostile individuals.

Accomplishment

AFRL recently built two prototype PHaSR weapons systems, delivering one to the Department of Defense (DoD) Joint Nonlethal Weapons Directorate (JNLWD) and the other to the Department of Justice National Institute of Justice (NIJ).



The JNLWD and NIJ recently awarded AFRL $350,000 and $250,000, respectively, to develop a second-generation PHaSR prototype that incorporates an eye-safe laser range finder. PHaSR will use this range finder to maximize the laser energy directed at targets, while maintaining eye-safe operations.

Background

PHaSR started in 2001 as an AFRL in-house effort known as the Portable Efficient Laser Test Bed. When the DoD's JNLWD provided funding in Fiscal Year 2004, they changed the program name to PHaSR. Shortly after AFRL received JNLWD funding, the NIJ also became interested in PHaSR and provided additional funding.

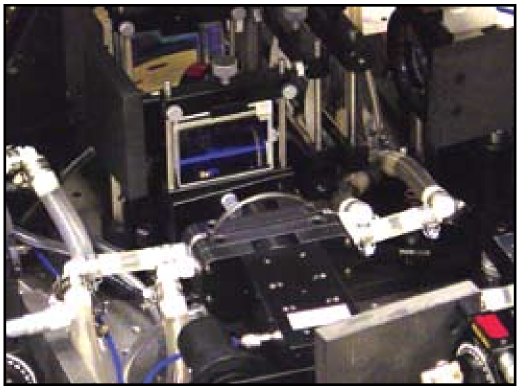
In the past, nonlethal laser weapons systems had to operate at a particular distance from their targets; they were too powerful at close ranges and ineffective at longer ranges. While the first-generation PHaSR prototype operates within this same constraint, the JNLWD's and NIJ's funding of the next-generation prototype will tackle this problem by incorporating an eye-safe laser range finder. AFRL expects to deliver this second-generation PHaSR prototype in 2006.

AFRL Demonstrates High-Powered Spinning Disk Laser

Payoff

The military needs high-powered lasers, such as solid-state lasers, for tactical missions. Solid-state lasers are an enabling technology for many envisioned scenarios due to their small system size, all-electric operation, and low life-cycle costs. However, thermal problems are an issue when operating solid-state lasers at very high powers.

Spinning disk laser architectures control the effects of thermal loading in solid-state laser gain media. This technique dramatically reduces the possibility of damage from overheating the solid laser material, while also reducing thermally induced beam distortions. Additionally, this technique may allow scaling to tactically significant power levels.



Accomplishment

AFRL scientists recently demonstrated a spinning crystal disk (1.1 atomic% neodymium [Nd]:yttrium aluminum garnet [YAG]) laser at an unprecedented 750 W continuous wave output power. Spinning a large disk of gain material in a laser cavity spreads waste heat throughout the entire disk.

AFRL scientists procured an apparatus to precisely rotate and cool disks of solid gain material and then designed a laser system around this apparatus that produces high-quality (diffraction-limited) continuous power. As a laser gain material, Nd:YAG exhibits good thermal characteristics under continuous operation.

Initial disk experiments using 80 W of diode-laser pumping generated 27 W of diffraction-limited output power from one disk. In separate experiments, AFRL scientists experimented with diode stacked laser pumps with higher power levels than the diode-laser pumps, eventually generating 112 W of output power from one disk.

Finally, AFRL scientists pumped three Nd:YAG disks, 80 mm in diameter and 2 mm thick, with two 550 W diode stacked laser pumps per disk and achieved 750 W of output power. They actively cooled the laser gain material with cold metal plates spaced 20 μm from the faces of the disk, allowing heat conduction across the air gap. Future efforts will include experiments with other crystals and transparent ceramic gain materials.

Background

AFRL scientists expect semiconductor lasers to meet the majority of Air Force tactical requirements, in the low to middle power range, over the next decade. Spinning disk lasers offer a compact, efficient, low-cost option for addressing warfighter needs in this time frame.

Beyond scaling disk size, scientists can generate additional power by using multiple disks in a single laser cavity. With optimal thermal loading in each disk, they can essentially build arbitrary amounts of power and gain into a low-distortion resonator or amplifier chain.

AFRL scientists want to apply the spinning disk architecture to other laser materials, such as thulium (Tm), as well. They have scheduled testing of a Tm:YAG device, which has potential as an eye-safe (2 μ wavelength) laser scalable to high powers. Once proven in tactical applications, this technology's many uses will become available for current and future weapon systems.

AFRL Completes Defense-Wide Special Technology Area Review on Displays

Payoff
The Department of Defense (DoD) invests in opportunities with forseen military advantages. A defense-wide science and technology (S&T) strategy for displays will help align research efforts and yield multiple benefits across the DoD.

Accomplishment
AFRL chaired a special technology area review (STAR) for the Director of the Defense Research & Engineering (DDR&E) Advisory Group. This review assessed all defense display applications and industry technology trends for the DDR&E Advisory Group on Electron Devices (AGED). The resulting 120-page STAR report recommended that AGED assist the DoD in pursuing a defense-wide S&T display strategy. The Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics published the report.

Background
To assist in devising the S&T display strategy, AFRL established a 17-person triservice team of government technical experts, who worked with AGED to develop reference terms for the study. Members organized a 2-day workshop with 28 industry and academic speakers and drafted presentations into a 100-page "basis" document. With the team's support, AGED developed its findings and recommendations. In response to the work, the US Army Research, Development, and Engineering Command established a flexible display initiative.

AGED approved 18 findings and 4 recommendations to DDR&E. The recommendations pertained to manufacturing access, program coordination and planning, investment and payoff, and technology transfer and transition. Investment and payoff areas include ultraresolution devices and systems, true three-dimensional monitors, intelligent displays with embedded computing and sensing, avionics cockpits, flexible displays, miniature displays for helmet and sighting systems, and basic research.

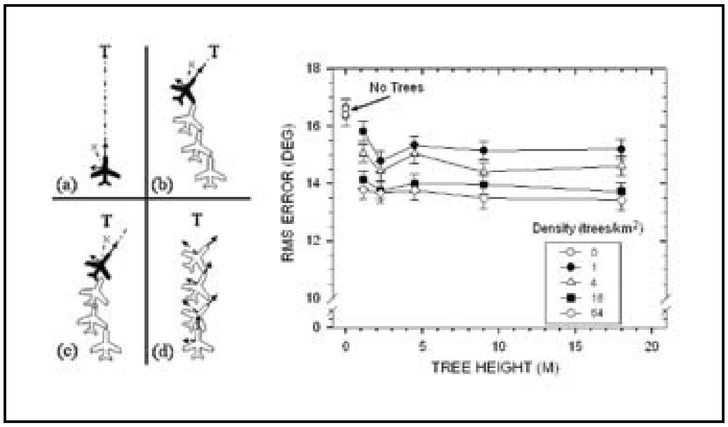
Accuracy of Heading Performance in Low-Altitude Flight

Payoff

AFRL collaborated with a National Research Council Fellow to evaluate simulator system performance. To collect the research data, the team identified the visual cues required for simulator task performance. This research will help determine the minimum database content that pilots require to accurately control travel direction (i.e., heading) during simulated, low-altitude flight (LAF). Three-dimensional (3-D) object simulation is expensive; however, scientists can conserve simulator resources if terrain detail replaces 3-D objects in providing the visual cues needed for task simulation. The research data indicates the potential for controlling simulated aircraft heading and providing a better understanding of the visual processes underlying visual direction perception.

Accomplishment

Scientists developed experimental techniques to estimate the root-mean-square (RMS) error in heading as participants attempted to fly toward a target by the shortest possible path. Simulated wind gusts displaced the aircraft position, requiring the subject to point the aircraft in a different direction. Scientists estimated the RMS error from the difference between the actual aircraft heading and the heading corresponding to the most direct path to the target. They determined that the presence of 3-D objects significantly improved heading performance. Improvement continued as object density increased from 1 to 64 objects per square kilometer. Heading performance did not improve significantly for object heights greater than approximately 1 meter.



Background

State-of-the-art flight simulators consist of many components, including image generators, graphics cards, and display devices. Each component can limit overall heading performance. LAF is a visually demanding flight task that scientists cannot adequately simulate in full-field flight simulators. In addition, the system-related deficiencies that limit the effectiveness of LAF simulation are not well understood. In the case of heading control, the most obvious visual cue is the overall pattern of relative movement of terrain elements and/or simulated 3-D objects. Researchers designed the present study to investigate the relative contribution of terrain and 3-D object cues to LAF heading task performance.

AFRL Demonstrates True 3-D Heraldic Display for Commanders

Payoff

A true three-dimensional (3-D) display capability will help collaborative decision makers view and understand the spatial relationships between air and land targets, enabling commanders to visualize battlespace dynamics. AFRL researchers recently demonstrated a first-generation system with limited capabilities.

Accomplishment

AFRL, in partnership with Actuality Systems, Inc. (Burlington, Massachusetts), recently provided a volumetric 3-D visualization system, thereby simultaneously giving commanders a walk-around electronic crystal ball on the battlespace and supporting initial transition to Air Force top leadership. This AFRL 3-D system provides volumetric information that is inherently understandable and simultaneously viewable by multiple warfighters in a command or control center. This new capability enables personnel to acquire and maintain an awareness of battlespace assets at a glance—a view of operational dynamics that deployed two-dimensional (2-D) visualization systems currently do not provide. However, this first-generation system is limited in the overall scene complexity and dynamics that it can display.

Background

Commanders and operations personnel ordinarily establish and maintain a mental model of the dynamic battlespace environment via a series of 2-D views generated from restricted viewpoints. AFRL personnel acquired a commercial off-the-shelf, true 3-D system with a rotating screen. In a previous program, AFRL developed an ultrafast, digital micromirror device light engine, which enables and powers the rotating screen.

AFRL-developed software enables generation of datasets of interest, and the laboratory demonstrated the potential for visualization of 3-D datasets, such as unmanned air vehicle and lidar. AFRL developed a research program comprising the following thrusts: (1) hardware development via Small Business Innovation Research efforts; (2) software development to enable operators to view computer-generated, 3-D content of their choice; (3) scenario evaluation to place current, true 3-D hardware in a representative application environment to obtain user feedback; and (4) metric development to enable objective and subjective measures of effectiveness to guide science and technology investments.

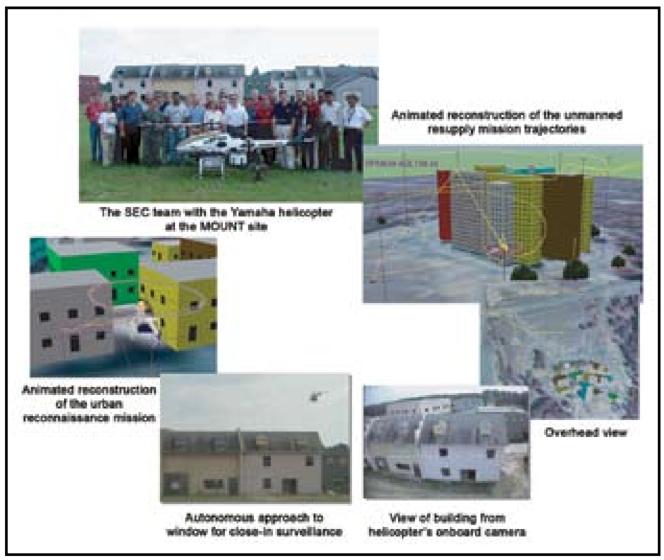
Autonomous Control of Small UAV Rotary Wing Demonstrated

Payoff

Georgia Tech (GaTech) demonstrated autonomous control of several small unmanned air vehicles (UAV) at Fort Benning's Dismounted Battlespace Battlelab, McKenna Military Operations in Urban Terrain (MOUNT) site. This effort, funded by the Defense Advanced Research Projects Agency and managed by AFRL, showcased work from several technology developers: Boeing; Draper, Inc.; GaTech; Honeywell, Inc.; the Oregon Graduate Institute; Vanderbilt University; and Scientific Systems Company, Inc.

Accomplishment

AFRL was responsible for transition partnering, technical guidance, and contract management for this 5-year effort. Scientists conducted three successful experiments to demonstrate high-level autonomous control for several UAVs in an urban setting.



The first demonstration involved autonomous trajectory generation, mode transitioning, fault tolerance/low-level control, and extreme maneuvers on the Yamaha R-Max UAV platform. The second demonstration showcased autonomous, vision-aided inertial navigation; surveillance of a moving target in urban terrain; extreme maneuvers, such as envelope protection and fault tolerance; envelope reshaping; and trajectory generation on the R-Max. Scientists conducted the final demonstration using a micro air vehicle (MAV) that involved the development of a very small autopilot system in terms of both its hardware (credit-card-sized) and its software. The test was the first of its kind for a very small MAV to fly autonomously.

Background

Researchers are pursuing transition of these technologies to the US Army, Air Force Special Operations Command, and US Special Operations Command. For the first application of extreme maneuverability, surveillance in an urban setting, and fault tolerance, scientists will integrate technologies into the A-160 Hummingbird UAV program that is intended for use by the US Army and special operations community. All of these software-enabled control (SEC) technologies will be used to reduce risk on the new urban command, control, and identification safety range program entitled Heterogeneous Urban Reconnaissance, Surveillance, and Target Acquisition Team.

AFRL Participates in Successful Phased-Array Antenna Demonstration

Payoff

AFRL and the Air Force Space Battlelab (AFSB) successfully demonstrated a six-panel S-band electronic scanning antenna (ESA) for satellite telemetry, tracking, and command (TT&C). The ESA, demonstrated at the Wallops Flight Facility, Virginia, will provide TT&C for Air Force, National Aeronautics and Space Administration (NASA), and National Oceanic Atmospheric Administration satellites. Satellites require timely TT&C for payload operation; consequently, AFRL developed a 6-panel subarray as part of a multibeam, geodesic dome phased-array antenna (GDPAA), which will greatly increase satellite communication links for the Air Force Satellite Control Network (AFSCN) and NASA and provide more reliable TT&C and communications.

Accomplishment

AFRL teamed with the Space and Missile Systems Center, the AFSB, The Aerospace Corporation, four Small Business Innovation Research project contractors, and Ball Aerospace to design, fabricate, and test a six-panel ESA and demonstrate the feasibility of providing TT&C and communications to satellites. The six panels are a proof-of-concept subarray of the GDPAA envisioned to replace the AFSCN's existing, mechanically steered dishes, which provide TT&C and communications signals to Department of Defense and NASA geosynchronous, medium earth orbit, and low earth orbit satellites. Ball Aerospace, under contract to the AFSB, integrated the AFRL components into six combined panels.

Using AFRL's Portable Universal Ground Processing Unit for remote monitoring of TT&C signals, researchers demonstrated TT&C equipment reduced in size by a factor of 6. The ESA performed all required modes of operation during its Space Ground Link Subsystem (SGLS) and NASA Unified S-Band (USB) satellite contacts. The six-panel array commanded the satellites to turn on transponders with S-tones. The team used available test equipment to achieve carrier lock, demodulator lock on the sidebands, and bit synchronous lock, thereby showing proper telemetry operation. After computing the correct ranging values, the antenna operated in automatic tracking mode. The demonstration with TT&C and ranging covered all required modes of operation, verifying the ability to provide TT&C to satellites in different orbital paths using transportable AFSCN ground equipment and fixed NASA ground equipment.

Background

Researchers developed the S-band ESA array for TT&C and communications at SGLS and USB frequencies to meet the AFSCN's growing operational needs. The six-panel array testing served to validate the technologies proposed for a full-size, 10-meter diameter GDPAA. NASA and AFSCN operators provided satellite control authority and satellites. The 6-panel demonstration results prompted the GDPAA team to propose a 54-panel technology demonstration. This proposed study would supply a multiple simultaneous link TT&C capability and promise Air Force Space Command a satellite control and communications antenna to alleviate its predicted satellite operations overload.

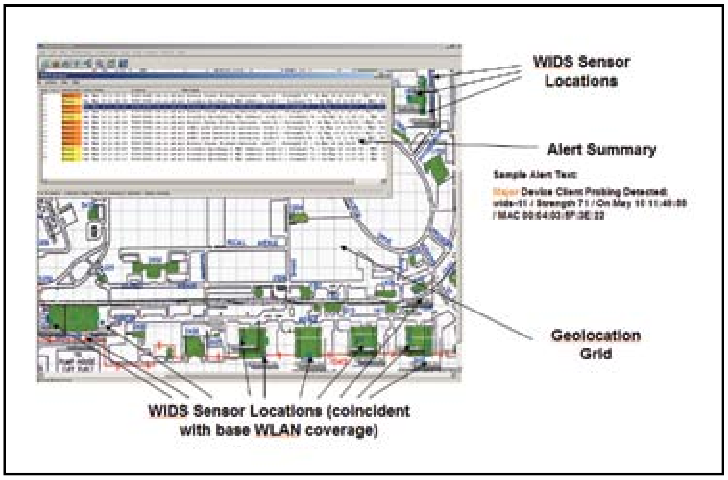
AFRL Develops Intrusion Detection and Policy Monitoring for Wireless Networks

Payoff

AFRL developed security technology to allow network managers to monitor wireless networks for compliance and identify signs of network activities and attacks in real time. The laboratory is actively pursuing transition of this successful technology to the warfighter.

Accomplishment

AFRL successfully demonstrated its wireless intrusion detection system (WIDS) at Westover Air Reserve Base, Massachusetts, culminating a weeklong military utility assessment. The program—dubbed "Project Martin" as an analogy to the bird that eats flying insects while in flight—demonstrated WIDS' capacity to capture wireless pests in real time. Project Martin included the Air Force Operational Test and Evaluation Center and the 92d Information Warfare Aggressor Squadron as independent evaluators of the system.



WIDS was able to detect and geolocate attackers and also interface with standard network management tools such as Hewlett-Packard OpenView™, all with minimal impact to the network's operational performance. The laboratory began development of a next-generation system, WIDS-X, which meets existing and emerging Air Force requirements for wireless network defense. WIDS-X will include refined operator and configuration interfaces, active response mechanisms, remote vulnerability scanning, access point functionality, integration with additional network management systems, and an extended three-dimensional geolocation capability. Based on a new dual-radio platform, WIDS-X will also include several system security and communication protocol improvements to the underlying system architecture.

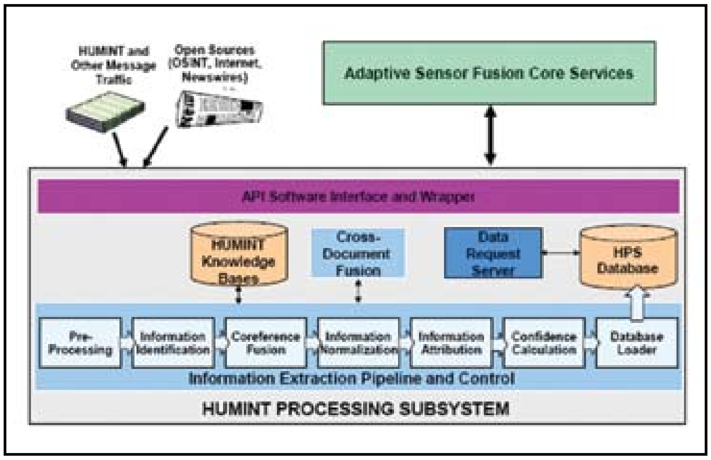
Background

AFRL is working with the Electronic System Center's Combat Information Transport System Program Office and the Air Force Information Warfare Center to explore the possibility of full commercialization and inclusion of WIDS-X as a standard component of the base network infrastructure. AFRL is also exploring several civilian technology transfer opportunities, including industry, law enforcement, and homeland security.

AFRL Develops Text Information Extraction Technology

Payoff

The development of multi-intelligence fusion technologies is critical to ongoing research efforts directed at the problem of anticipating, finding, fixing, tracking, targeting, engaging, and assessing stationary and moving targets.



Accomplishment

AFRL is developing an information extraction technology called the HUMINT (Human Intelligence) Processing Subsystem (HPS), which automatically extracts and infers information from text-based messages. HPS identifies all potential targets in a message, including their locations, dates and number of times sighted, and any evidence that could further assist in tracking and identifying the target type. HPS extracts entities that represent facilities and equipment and/or persons and organizations—along with each entity's associated locations, dates, times, and other notable characteristics—and stores this information in a database for use by downstream systems.

Potentially valuable characteristics include target count (e.g., "two tanks"), target state (e.g., "present", "missing", "damaged"), target size and color, and target speed and direction of travel (for mobile targets). Within a document, multiple references to a single entity via name, pronoun, or alternative descriptor (e.g., "George W. Bush," "he," "the President of the United States"), are said to "coreference" that entity; HPS recognizes coreferences and presents them as associated entities.

HPS associates a confidence measure with each identified entity to express the likelihood that the interpretation of the entity or its association with other entities is accurately represented. For example, confidence measures indicate whether an extracted item was actually referenced in message text (e.g., "high", "medium", "low"), evaluate the intelligence reporter's source (e.g., "new", "reliable"), and relay the reporter's confidence in his or her sightings (e.g., "possible", "probable", "confirmed").

Background

AFRL personnel used HPS to participate in the Joint Expeditionary Force Experiment conducted in the summer of 2004 (JEFX-04). During the experiment, HPS performed entity extraction on simulated intelligence messages. HPS saved the extraction results to a database for use by the Intelligence Fusion System, which correlates and fuses multiple-source sensor data to identify, locate, and track targets. The Web-Enabled Timeline Analysis System, a visualization toolset developed at AFRL's Rome Research Site (New York), ultimately used this information to display mobile targets on map displays.

With the successful performance of HPS during JEFX-04, AFRL clearly demonstrated the significant value of automatically processing text messages and providing the pertinent information contained within those messages to other systems in an Air Operations Center environment.

AFRL Technology Enables True "Effects-Based" Predictive Battlespace Awareness

Payoff

AFRL's Predictive Awareness and Network-Centric Analysis for Collaborative Intelligence Assessment (PANACIA) system will serve as a key enabling capability for the Joint Expeditionary Force Experiment 2006 (JEFX-06). It will support the Fusion in the Air Operations Center (FAOC) initiative to integrate all source intelligence information collected from multiple sensor platforms—in constructive simulation as well as live-fly activities—during JEFX-06. The FAOC system will correlate and "reason on" the integrated information to provide real-time updates to emerging target sets in the battlefield. This real-time update capability and its integration with dynamic operational execution, as well as planning, serve as the basis for fielding a true "effects-based" predictive battlespace awareness capability.

Accomplishment

JEFX-06 leaders selected AFRL's PANACIA as a key enabler for the upcoming JEFX-06 effort. An innovative, operator-focused, and roles-based system, PANACIA provides adaptive multi-intelligence reasoning and fusion capabilities that span multiple intelligence domains. It integrates various systems from different agencies to address data needs ranging from simple tracking to complex behavioral reasoning, improving the Air Operation Center's (AOC) ability to integrate command and control, operations, and intelligence.

PANACIA will enable the FAOC initiative to field several first-time capabilities for the AOC. Key among these will be the real-time transmission—across security boundaries—of operational data to intelligence analysts and intelligence data to AOC operators and planners.

PANACIA will alert intelligence analysts to changes in the operational plan and/or its execution as such changes occur. In turn, the FAOC system will provide the AOC's Combat Operations Division with real-time intelligence data relevant to the ongoing battle, as well as dynamic execution elements of the plan.

In addition, PANACIA will be instrumental in supporting distributed operations. It employs a novel collaboration capability, enabling analysts to exchange complex information far more efficiently than current Internet Relay Chat functions permit.

Background

PANACIA leverages existing and highly successful fielded AFRL technologies, including the Web-Enabled Timeline Analysis System and the Moving Target Information Exploitation system, as well as national agency capabilities provided by the Analyst Support Architecture system. Ultimately, PANACIA will provide a transitional capability to streamline the process of real-time intelligence analysis and its support to ongoing combat operations.

AFRL Develops System for Standoff Detection of Human-Carried Explosives

Payoff

AFRL, in conjunction with small business, Science Engineering Technology (SET) Associates, is developing a system that can detect human-carried explosives (HCE) at appropriate standoff distances. Successful development of this system will provide deployed forces with reliable protection from suicide bombers. Phase I project results indicate that a standoff HCE detection and tracking system is feasible and practical. The project's evaluated technologies provided solutions to several challenges in explosive detection technology, including increased discrimination potential, a smaller logistical footprint, and reliable operation from distances that provide maximum warning. Researchers expect Phase II to result in rapid development and field testing of a prototype system to meet this urgent and compelling need.

Accomplishment

AFRL scientists and engineers, executing a Small Business Innovation Research agreement with SET Associates, completed the HCE project's first phase. Phase II leverages Defense Advanced Research Projects Agency and AFRL funding to develop a system prototype and evaluate its performance against a variety of improvised HCE device threats. Researchers expect the completed system to significantly improve military force protection efforts.

Background

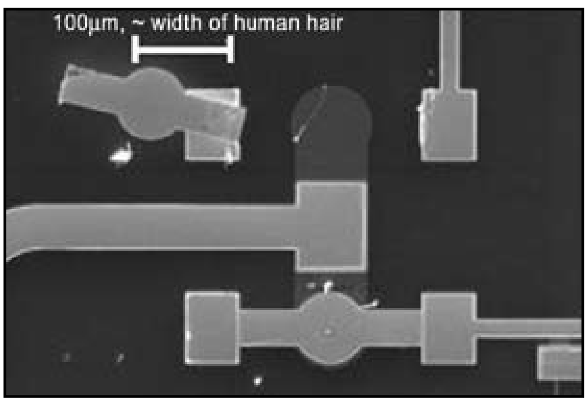
Existing explosive detection technologies have several key limitations. For example, portal detection systems are suitable for fixed location deployments where operators can use access control to channel subjects through the detection system; however, portal detection systems are not appropriate for all military force protection efforts, particularly those requiring standoff range. In addition, technical challenges such as small target radar cross sections and environmental clutter hinder active radar solutions.

The AFRL and SET team conceived a low-cost, high-performance system design that military security forces can easily and reliably operate. The system automatically detects threats up to 100 meters away and sends a threat warning to a mobile handheld display. The field operator reads the display and determines the appropriate measures to handle the situation. A database archives video clips, radar signatures, threat status, and contextual data, enabling further analysis of terrorist activities and opportunities for system enhancements.

Unique MEMS Switch Simulator Uncovers Material Property Opportunities

Payoff

AFRL scientists developed a highly sophisticated laboratory instrument that simulates the effects of physical forces and electrical current on microelectromechanical systems (MEMS) switches. MEMS radio frequency (RF) switches provide significant advantages over current electromechanical (EM) and solid-state (SS) switches. These advantages include high linearity, low insertion loss, low power consumption, reduced size, high shock resistance, wider temperature range, good isolation, and low cost. Enhanced performance and reliability will lead to improvements in existing systems and create a new paradigm for future system development. Functional MEMS RF switches will benefit the Air Force and the private sector in important areas such as radar, aviation instrumentation, and cellular phones.



Accomplishment

The simulator's performance, honed through meticulous attention to detail over many years of investigation, has led to revolutionary insights into microscale switch characteristics. MEMS switches offer substantial performance enhancement over current EM and SS switches and demonstrate great potential for military and commercial applications, with promising RF applications. AFRL scientists used their in-house-built simulator in a unique way: to study contact resistance and microscale surface forces in gold contacts used in direct current MEMS switches. They then connected fundamental properties to performance, with an emphasis on the effects of contact force and electric current on resistance, microadhesion, reliability, and durability.

Background

MEMS switches, so small that they require high-powered microscopes to be seen, offer a significant performance edge over EM and SS switches. Realizing this potential, however, requires a greater understanding of the contact physics of electrode materials, which can be attained only through improved knowledge and a better characterization of material properties down to the nanoscale. Among the switch devices presently used in RF systems, EM relays offer the best high-frequency performance in terms of low insertion loss, high isolation, and good power handling (up to several watts).

Unfortunately, EM devices are large, slow, and expensive, and they also lack durability. Conversely, SS switches offer chip-level integration, small size, fast switching times, excellent durability, and low cost. However, as a rule, they do not perform well in broadband applications, and they exhibit high insertion loss and poor isolation. As a result, the choice between EM and SS switching generally involves a trade-off between EM high-frequency performance and SS durability, reduced size and cost, and faster switching speed. Another consideration is that high losses in SS switches tend to nullify their size benefits due to the need for signal amplifiers, which increase power consumption and complexity. Thus, the attraction of MEMS RF switches is their capacity to offer the performance of EM switches, combined with the durability, smaller size, and low cost of SS devices.

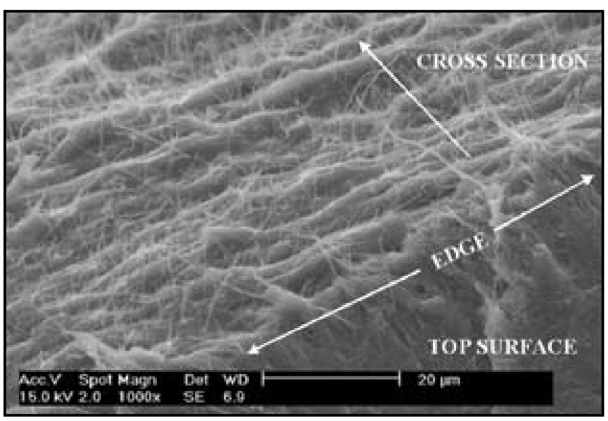
AFRL Develops Method to Form Conductive Polymeric Nanocomposite Materials

Payoff

AFRL scientists developed a method to increase the conductivity of polymeric material with carbon nanofibers. Scientists can use the resulting polymeric nanocomposites in conductive paints, coatings, caulks, sealants, adhesives, fibers, thin films, thick sheets, tubes, and large structural components that aerospace and industry applications require. Some of the technology areas that will benefit from this method are electromagnetic interference shielding, electromagnetic pulse hardening applications, electrical signal transfer, electrostatic painting of panels, electrostatic discharge, and electro-optical devices (e.g., photovoltaic cells).

Accomplishment

Nanoscience and technology afford unique opportunities to create and exploit revolutionary material combinations. Such combinations synergistically enable new properties only when the materials' morphology and fundamental physics coincide on the nanoscale. The laboratory-developed method enhances the materials' dimensional stability, abrasion resistance, electrical and thermal conductivity, and tribological properties such as reduced surface friction. AFRL expects that scientists will use the invention to develop a wide variety of commercial and military applications for aerospace, electronic, automotive, and chemical technologies.



Background

The program's resulting methodology provides a process to uniformly disperse vapor-grown carbon nanofibers into various polymer matrices. The method of forming conductive polymeric nanocomposite materials incorporates nanofibers with a solvent to form a solution mixture, and adds a polymer to the solution mixture to form a substantially homogeneous mixture. The solvent is subsequently removed from the mixture by evaporation or coagulation.

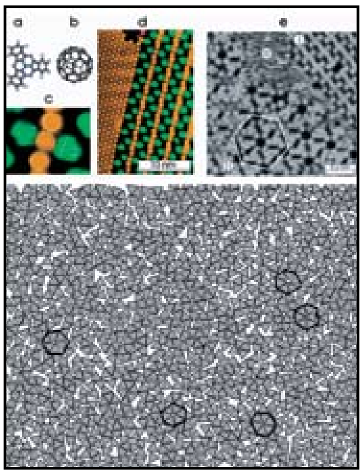
The invention relies on selection of the required polymer from the polyurethane, polyimide, epoxy resin, silicone polymer, and aromatic-heterocyclic rigid-rod and ladder polymer groups. Laboratory scientists most commonly select the solvent from the group consisting of dimethyl sulfoxide; tetrahydrofuran; acetone; methanesulfonic acid; polyphosphoric acid; and N,N-dimethyl acetamide. Further, they suggest that both the polymer and the solvent should be somewhat polar.

AFRL is currently conducting follow-on research to develop a metal-coated nanotube for nanocomposites. This material would provide greater conductivity for signal wire shielding and other applications where reduced thickness and increased conductivity are imperative.

Breakthrough Computer Modeling Uses Artificial Intelligence to Examine Materials

Payoff

AFRL scientists made a fundamental breakthrough in the development of new computational methods that hold great promise for enabling technologies that are vitally important to future Air Force systems. Computers can predict the properties of bulk materials before they are made; therefore, scientists can shorten development time by using computers to model new forms of matter with high fidelity. The computer is capable of deductive reasoning and providing design limits for previously nonexistent material types.



Accomplishment

AFRL's ability to perform larger and more rapid computations is a generic capability enabling a wide range of fields, including new material design and intelligent systems for collision avoidance and autonomous vehicle control. AFRL completed its first published studies, and related research is under way at Cambridge University (United Kingdom) and Tohoku University (Sendai, Japan). AFRL's artificial intelligence (AI) computer modeling approach allows far more rapid and realistic simulation of materials than previously possible. Scientists have demonstrated the approach on two samples and revealed some exceedingly interesting new physical phenomena of critical importance in the emerging field of nanoscience and technology.

Background

Computational materials science methods can benefit the design and property prediction of complex real-world materials. With these models, scientists and engineers can design molecules as building blocks and investigate how they can assemble the blocks—including possible defects—to produce fundamentally new kinds of matter. The laboratory's use of computer modeling with AI is an untried approach in the field of statistical mechanics and thermodynamics. Using this approach, the computer first learns the collision dynamics of the given complex objects and then saves this knowledge to carry out the actual calculation during the simulation.

AFRL SBIR Effort Results in Materials Knowledge Base Technology

Payoff

A team of AFRL scientists, engineers, and developers partnered with RJ Lee Group, Inc., to complete the development of a functional prototype of the materials knowledge base (MKB), an object-oriented data repository for laboratory and materials characterization information. The MKB, part of a Small Business Innovation Research (SBIR) Phase II enhancement project, demonstrates enormous potential to affect the way AFRL collects, processes, stores, and shares data.

Accomplishment

The MKB SBIR project resulted in a prototype object-oriented knowledge base and data management system that supports AFRL's aerospace materials research and development efforts. The system demonstrates the potential for unprecedented project collaboration and data accessibility. RJ Lee Group used the SBIR Phase I work to create a functional prototype for AFRL. They focused on AFRL's carbon foam research, although the resultant system is not designed specifically for any particular class of materials or application.

This system, which runs on all operating system platforms, features two main components: a desktop application and a server-based data repository. The desktop application, loaded onto each user's personal computer, provides a structured environment for the user's personal project data. Users have a desktop application tailored to their specific needs and preferences to allow fast, precise input and personal storage of laboratory data. In this capacity, MKB is a tool for scientists and engineers to manage their workflow and projects. Users can introduce charts, reports, drafts, and other data to the system as resources (or files) that they can group and organize into collections (or folders).

The second primary feature is a server-based data repository. Through this repository, each user can upload his or her project data to share with other users of the knowledge base. MKB can link data from a wide variety of sources and formats. It makes the data accessible in a controlled environment and maintains the security of sensitive information. Users can easily search and sort the data, but only the originator can make modifications when subsequent data becomes available.

Background

In the world of materials research and development, there is a growing need to accelerate the introduction of new materials and enhance the discovery of existing materials. One avenue for satisfying these needs is a set of information management techniques that improves the ways in which the world exchanges materials data.

RJ Lee Group, in conjunction with AFRL, proactively pursued the development of these technologies during the MKB SBIR project. The overall technical objective of the SBIR Phase I project was to provide a proof of concept, using AFRL's carbon foam research as the basis. Scientists also identified key technologies for potential use in the ultimate implementation of MKB.

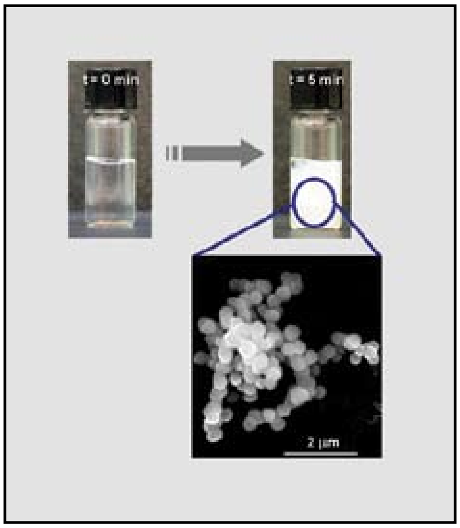
Silica-Binding Peptides Advance Understanding of Inorganic Materials Synthesis

Payoff

AFRL scientists are using processes borrowed or adapted from living organisms to make important strides in the quest for new materials for advanced structures. Working at the billionths-of-a-meter scale (i.e., nanoscale), they demonstrated that it is possible to identify and isolate the peptides—the building blocks of proteins—needed to bind and precipitate silica from a solution of silicic acid. Inorganic materials such as silica play a critical role in military and commercial systems due to their favorable electronic and thermal properties. This ability to control inorganic material formation can lead to the development of important new materials and low-temperature processing techniques for the Air Force.

Accomplishment

The AFRL research demonstrates that peptides displayed by phages act as templates in inorganic material synthesis, and also provides a means to understand how some biological systems conduct materials chemistry *in vivo* (within the living organism) using ambient conditions. It also increases the understanding of the biological interactions necessary for silica nucleation and precipitation. The team demonstrated that combinatorial approaches are effective in rapidly selecting surface-specific peptides and identifying a subpopulation of silica-precipitating peptides from a larger pool of binders.



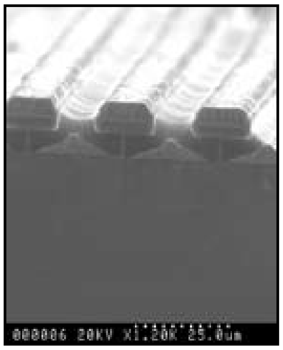
The AFRL research supports the notion that scientists can partially or completely control biomineral properties such as particle size, shape, crystal orientation, polymorphic structure, defect texture, and particle assembly. Scientists can exercise this control through specialized proteins that recognize specific crystal surfaces during crystal growth. The investigation of silica production using short proteins known as peptides is advancing the understanding of biomineralization and inorganic materials synthesis *in vitro* (in the laboratory).

Background

Phage display uses bacterial viruses, known as phage, for display on surface peptide sequences. The phage is genetically engineered so that a particular peptide fuses to a protein on the phage's coat, with the gene encoding the displayed peptide contained inside the phage particle. This technology couples the displayed peptide's phenotype to its genotype, allowing easy retrieval of the deoxyribonucleic acid that codes the selected peptide. A typical phage peptide library contains a billion different peptide sequences.

Isolating peptides from a combinatorial phage display library allows researchers to synthesize and/or assemble inorganic components on the nanoscale. Arranging and depositing inorganic materials with the use of peptides provides an alternative to extremely difficult and costly conventional deposition techniques. In addition, the use of peptides in the synthesis of inorganic materials can provide excellent spatial control over the placement of these components on a substrate. By controlling the deposition of the templating peptides on a substrate, researchers can control the mesoscopic properties of materials by choosing the correct molecular characteristics.

AFRL/Industry Research Effort Improves Semiconductor Film Quality

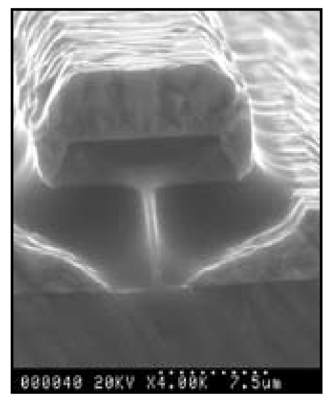


Payoff

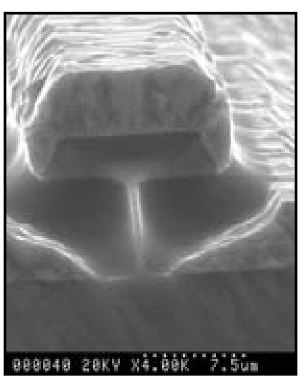
AFRL scientists worked with Gratings, Inc. (Albuquerque, New Mexico), to demonstrate the feasibility of producing improved-quality semiconductor films to support a diverse range of advanced military and commercial applications. They achieved capabilities in this research and development effort that could lead to major improvements in semiconductor films used in optoelectronic integrated circuits; near-infrared photodetectors; and low-cost, lightweight, high-efficiency solar cells with high mechanical strength.

Accomplishment

AFRL and Gratings reduced the density of defects—misalignments and dislocations in the atomic layering—by a factor of 10,000. They completed the effort under an Air Force Small Business Innovation Research (SBIR) project. Their research focused on the heteroepitaxial growth of gallium arsenide and germanium on silicon (Si) surfaces. This accomplishment could have tremendous impact on the performance of semiconductor devices for future warfighting systems and commercial products.



AFRL and Gratings' SBIR effort expands the potential for extremely high quality semiconductor films. The work also resulted in the development of innovative techniques for Si quantum wire fabrication and si-on-insulator configurations. The researchers earned a patent for the technology, which they developed under the SBIR project over a 5-year period.



Background

The quest for new and improved electronics and photonic devices drives the continual pursuit of epitaxial technique advancements and a clearer understanding of epitaxial growth's underlying physics. Scientists use epitaxial techniques to match the orientation of a deposited crystal with the orientation of the crystal that comprises the underlying substrate material. When the crystal orientations of two or more different materials (heteroepitaxial) are not properly aligned, defects (i.e., misalignment and dislocation of atoms) occur. An accumulation of these defects is known as the defect density. AFRL is exploring ways to reduce defect density and thereby increase semiconductor efficiency.

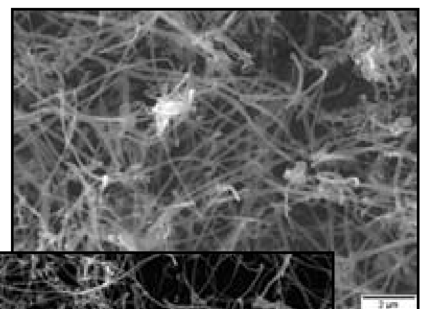
AFRL Reaches a Milestone With Vapor-Grown Carbon Nanofibers

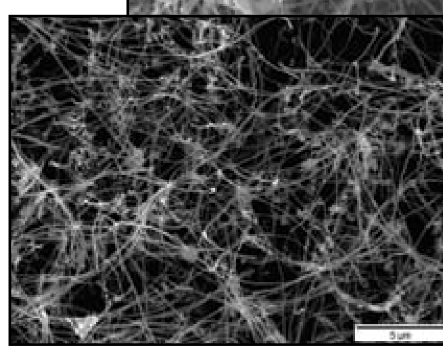
Payoff

AFRL and Applied Sciences, Inc., worked under a Small Business Innovation Research (SBIR) contract and reached a milestone by producing a longer vapor-grown carbon nanofiber (CNF) with a constant diameter of ~150 nm. The nanofibers can improve heat distortion temperatures and increase electromagnetic shielding. The long-fiber development also enables production of freestanding paperlike sheets, which are useful for several military and commercial applications. Examples of commercial applications include cell phone shielding, lightning strike protection, and electrostatic discharging materials.

Accomplishment

AFRL and Applied Sciences developed nanofibers that simultaneously provide tailored electrical conductivity over a broad range and mechanical reinforcement for some composite matrix materials. The nanofibers typically grow to several tens of microns in length, but subsequent milling can reduce their length to fewer than 10 microns. The SBIR contract resulted in the modification of two nanofiber grades, PR-19 and PR-24. This result is due to a nondebulking process that preserves the length of the carbon nanofiber. PR-19 contains a chemical vapor deposition (CVD) layer and has a diameter of ~150 nm. PR-24 contains a minimal CVD layer and has a diameter of ~100 nm.





Background

Nanotechnology provides unique opportunities to create and exploit revolutionary material combinations that scientists can use to circumvent classic material performance trade-offs. Such combinations can synergistically enable new properties only when the materials' morphology (e.g., length scale) and the fundamental physics associated with the property coincide on the nanoscale.

CNFs are nanoscale cylinders of graphitic carbon with a high aspect ratio (the ratio of length to diameter). A CNF is generally composed of two phases of carbon. The catalytic phase is formed by the catalytic action of the metal seed particle from which the CNF grows. This phase tends to consist of well-ordered, graphitelike planes of carbon atoms; however, these carbon planes are slightly curved to form a cylindrical material rather than a sheet. The deposited phase is the result of carbon CVD on top of the catalytic phase.

AFRL Establishes Optical Properties for Scale-Up of Spinel Windows

Payoff

Manufacturers can use conventional low-cost ceramic processing technologies to fabricate spinel windows for military applications (such as targeting pods, missile domes, and transparent armor) instead of using costly sapphire. Substituting spinel for the baseline window material used for some applications could provide the Air Force (AF) with millions in cost savings.

Accomplishment

AFRL and Surmet Ceramics Corporation, of Burlington, Massachusetts, recently completed baseline optical testing of small spinel windows as part of an effort to scale up window sizes for potential use on AF infrared targeting and imaging systems. These systems provide aircraft with essential capabilities such as missile warning; laser spot tracking; and air-to-surface, forward-looking infrared tracking.

The AFRL and Surmet Ceramics test results indicated that spinel samples met standard electro-optical system specifications for transmittance, optical homogeneity, and haze. The testing confirmed that spinel possesses the required optical properties for many AF systems. This preliminary demonstration provides scientists the confidence to continue with the material's planned development.

Background

Scientists most commonly use sapphire as an infrared window material for weapons systems because it provides the properties required for high-performance windows and other military applications. However, sapphire is very expensive.

Spinel is a polycrystalline cubic material that exhibits properties similar to those of sapphire and polycrystalline aluminum oxynitride (ALON™). Manufacturers can process spinel from its polycrystalline form into transparent, optically isotropic components. Spinel provides an approximately 20% greater range than sapphire during air-to-air encounters, and manufacturers expect spinel to provide an approximate 50% cost savings over sapphire (hundreds of millions of dollars, depending on the number of applications). Spinel technology is transferable to a myriad of other military technologies and has the potential to generate additional savings across the AF inventory.

Spinel window technology also offers improved transmission compared to the current sapphire and ALON. Spinel is transparent to electromagnetic radiation from the ultraviolet through the midinfared range and has the added advantage of improved optical transmission in the 4.5-5.5 micron band over sapphire and ALON. This is of particular importance for seeker and electro-optic imaging systems.

Spinel is strong enough to resist the effects of the environment, but still provides optical properties equal to sapphire. Tests for assessing spinel's strength properties are ongoing, and AFRL engineers will closely track all demonstrated properties as they scale up to the required window sizes for future electro-optical systems.

AFRL Launches Industrial Base Information Repository

Payoff

The Air Force (AF) needs the capability to rapidly research actual and potential industrial base issues to identify their impact on AF materiel requirements. A Web-formatted, convenient, sector-organized industrial base repository would allow users to access, read, and copy/download any reports residing therein. Repository maintainers would add completed projects and reports to the site and respond to customer feedback directly through the Web.

Accomplishment

AFRL recently established the Industrial Base Information Center (IBIC) as an industrial base information repository to provide interested users with valuable insight into the world of industrial base planning (IBP). The IBIC's mission is to provide timely information about the Defense Technology and Industrial Base to directly support the planning and execution activities of AFRL and related government users.

The IBIC is the primary information source, reference, and data integrator for obtaining existing Manufacturing Technology, Defense Technology and Industrial Base, Defense Production Act, and Air Force Materiel Command Acquisition and Logistics information needed to execute AF programs. The IBIC provides AF activities the capability to rapidly research actual and potential industrial base issues to identify their impact on AF materiel requirements.

Background

To effectively support this essential AF mission, the IBIC actively subscribes and/or maintains access to a myriad of information sources as part of a dynamic process that provides timely, up-to-date, and complete response to a customer's request for industrial-base-related information in the most concise and useful form. Sources include those from online services, special-purpose government databases, Department of Defense (DoD) information analysis centers, and commercial CD-ROM and disk database subscriptions. The IBIC maintains unique databases for critical defense materials and industrial base information not readily available from other existing sources.

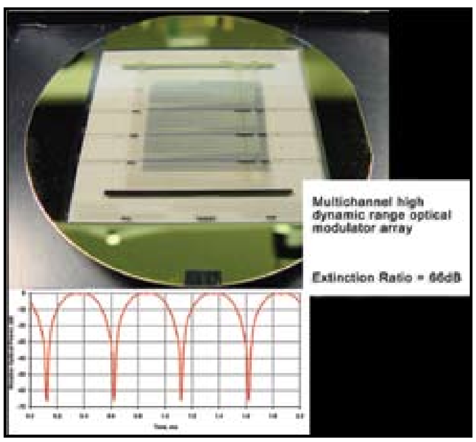
The IBIC developed an IBP Community of Practice (CoP) to make selected industrial base information more accessible to a wider user community. The IBP CoP includes a repository of completed reports, studies, and assessments prepared by a wide range of activities. Air Force Knowledge Now (AFKN) and Air Force Portal Web servers host this industrial base repository, which is available to all government employees and contractors having an AFKN/Air Force Portal login access credential.

The IBP CoP repository provides a simple search capability and includes an extensive collection of industrial base reports, analyses, and related documents prepared by the AF and numerous DoD offices and agencies. The repository also holds all IBIC reports from 1997 to the present.

Ultrahigh Dynamic Range Optical Modulators for LADAR Scene Projection

Payoff

AFRL funded the development of ultrahigh dynamic range optical modulators for laser radar (LADAR) scene generators used for sensor testing. Using Mach-Zehnder interferometer (MZI) technology as its platform, the electro-optic modulator device enables a 256 x 256 pixel array of optical sources that deliver nanosecond-timed optical pulses with the high dynamic range typical of real scenes.



Accomplishment

Under an AFRL Phase I Small Business Innovation Research contract, Srico, Inc., developed and successfully tested an ultrahigh dynamic range modulated optical source based on a compact MZI intensity modulator. Srico set a world-record 66 dB extinction ratio for an optical modulator, a ratio of about 4 million to 1. This will enable simultaneous processing of extremely small intensity and extremely large intensity image elements. The Air Force (AF) will be able to represent and simulate real-world scenes 40,000 times better than current practice permits. Srico also demonstrated device operation over a broad spectral band that will allow scene simulations at multiple optical wavelengths with a single system.

To achieve these groundbreaking results, the company used proprietary integrated optic waveguide designs and innovative fabrication processes. The design ensures that the dynamic range available is more than 10,000 times greater than the range commercial MZI modulators permit. The MZI device is capable of integration onto a larger optical chip containing 256 pixels.

Background

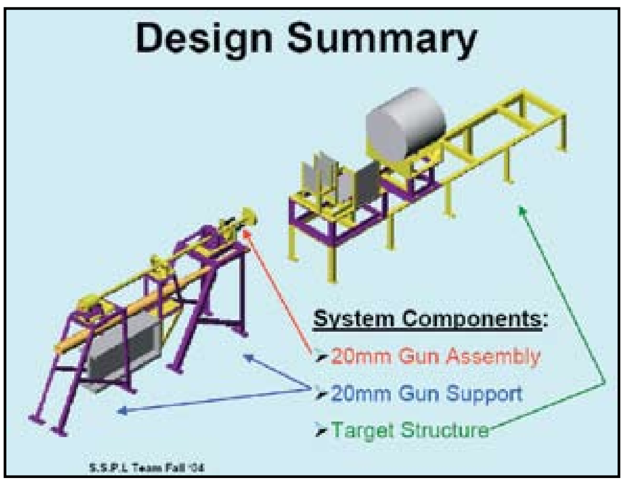
Advanced LADAR systems have emerged as a critical next-generation technology for military applications such as target recognition and ground navigation. The AF requires high-performance, low-cost, ultrahigh dynamic scene projector components for testing of LADAR scene generators. Compared with traditional imaging, LADAR offers the advantage of distance information for each pixel. Thus, each frame is really a three-dimensional (3-D) image. Although advanced LADAR systems are widely deployed for terrain mapping and navigation, scientists are developing a technology that will use two-dimensional focal plane array detectors and high-speed embedded computers to offer unprecedented resolution, speed, and usability. For example, computer assembly of multiple 3-D images taken from different vantage points allows high-confidence target identification even for partially obscured targets .

LADAR scene simulators are an important tool for characterizing missile and aircraft LADAR systems. Scientists use the scene simulator for incremental and final testing of the embedded hardware and software that enable real-time operation of the LADAR system. The scene simulator consists of a scene generator and an optical projection system. The scene generator is composed of software and electronics for generating real-time pixel signals. The optical projection system accepts this electronic drive signal and delivers a modulated optical signal to each pixel of the LADAR detector.

Collaborative Effort Develops Small-Scale Launcher to Investigate High-Strain Penetration Mechanics

Payoff

AFRL collaborated with mechanical engineering students from Louisiana State University (LSU) to develop a small-scale launcher to support high-speed penetrator phenomenology research. The new, 20 mm launcher allows AFRL greater control to investigate, design, and develop high-speed penetrator munitions technologies to defeat hardened, fixed, and deeply buried targets. The small-scale experiments are more cost-effective than the original, 50 and 127 mm launchers. The smaller launcher reduces turnaround time and operating costs and provides better diagnostics access.



Accomplishment

AFRL and the LSU team developed a new, 20 mm smooth bore launcher to support advanced penetrator munitions research. The LSU students provided an innovative concept, design drawings, and a prototype launcher, and they began initial characterization of the launcher. They completed 10 launches using 2 projectile masses at velocities from 2,000 to 4,000 feet per second, providing the experimental data to benchmark the launcher interior ballistics code to complete the turnkey capability.

As a result of this collaboration, the LSU engineering students benefited from a challenging real-world engineering problem, and AFRL received an efficient and effective capability without burdening researchers assigned to other critical munitions research efforts. As a reflection of their excellent teamwork and engineering skill, the student team received the Ben Burns Award for best project in the LSU Mechanical Engineering Department. In addition to the team award, each team member received an individual award.

Background

LSU requires senior mechanical engineering students to participate in a challenging two-semester capstone design course that provides an introduction to the real-world responsibilities of a design engineering professional. The student teams must select a project, complete the design, and build and test a prototype. The team also provides biweekly status reports and two status presentations each semester. The second semester culminates with the final project presentation and accompanying technical report documenting the effort. AFRL submitted the project idea, and LSU selected the laboratory to sponsor and guide this student team project.

AFRL Develops Active Vision for Control of Agile Maneuvering Air Vehicles

Payoff

AFRL is advancing imaging technologies to facilitate possible deployment of munitions and other air vehicles with autonomous sensing and control capabilities to detect, locate, classify, and prosecute collections of intelligently operated, mobile, defended targets. These air vehicles will be able to operate effectively in a covert manner and in proximity to structures/terrain. Imaging sensors play a major role for improving target recognition and tracking, obstacle/hazard avoidance, navigation, control, and cooperation. The agile imaging technologies will be able to coordinate maneuvers against dispersed targets through congested airspace and swarming attacks.

Accomplishment

AFRL is funding two Multidisciplinary University Search Initiative (MURI) projects to conduct basic research in the areas of active vision for control. The program objectives are to develop the fundamental theory, algorithms, and tools needed for autonomous active vision systems to provide agile air vehicles with real-time spatial awareness of complex environments. The program will also utilize sensory data from active vision systems for air vehicle guidance and control in complex environments, understand and characterize the limitations of active vision for guidance and control of autonomous agile vehicles in highly uncertain scenarios, and provide algorithms that can augment vision with other sensory information for use in these situations. To facilitate rapid technology transitions, both MURI project teams are working closely with AFRL to conduct joint experiments on the autonomous guidance, navigation, and control free-flight test bed, which is an experimentation facility that AFRL and the University of Florida Graduate Engineering and Research Center (UF-GERC) jointly developed.

Background

Current imaging guidance systems process imagery to detect, classify, and discriminate targets; they then use conventional intercept algorithms to attack the target. To realize the full potential of these new imaging technologies, scientists needed a new class of active-vision-based vehicle guidance systems to allow air vehicles to make real-time, context-sensitive responses based upon the imaging system's information. This will require multidisciplinary research in image processing methods, state estimation, guidance and flight control, and swarming and cooperative strategies applicable to air vehicles.

AFRL partnered with the UF-GERC to develop a free-flight test bed for experimental research on vision-based guidance. The test bed consists of several classes of small-scale airframes, hardware and computer support facilities, and image-in-the-loop simulation capabilities. A unique feature of this test bed activity is the commitment to experimentation on small-scale vehicles with onboard processing. This capability will complement the experimental test beds of the two MURI projects in an academic setting and will provide AFRL researchers with the technical insight to pursue guidance technology development for future munitions.

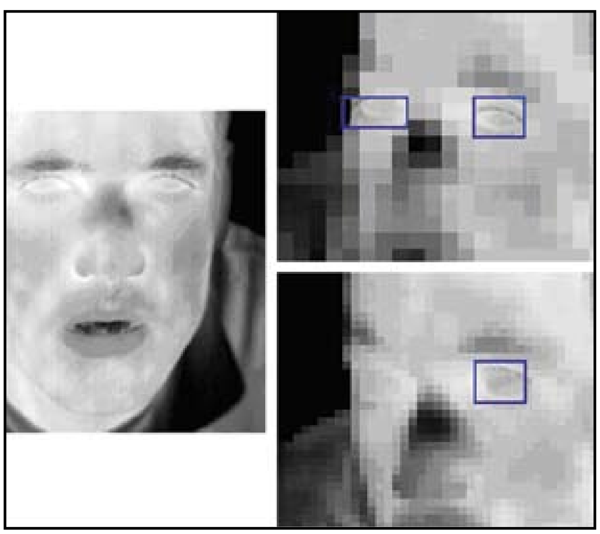
Breakthrough System Utilizes Foveal Vision Paradigm With Infrared Multiresolution Imagery

Payoff

Under a Small Business Innovation Research (SBIR) Phase II contract, Nova Research, Inc. (known as Nova Sensors), developed the first midwave infrared (MWIR) camera system with frame-to-frame, dynamically programmable spatial resolution. The multiresolution capability reduces bandwidth requirements for imagery transmission and processing. Its ability to operate in the infrared (IR) spectrum allows nighttime imaging, which further benefits the military. Optic flow calculation (using interleaved, low-resolution images) and wavelet decomposition (using the multiresolution capability) are a few of the technology's other advantages.

Accomplishment

Nova Sensors developed the Variable-Acuity Superpixel Imager (VASI™) under a Phase II SBIR contract to reduce the bandwidth required for IR imagery readout and processing, while maintaining maximum resolution foveae on regions of interest (ROI). This accomplishment maps the biologically motivated paradigm of foveal vision from the visible to the IR spectrum.



Background

Vertebrate eyes typically have a small area of high resolution (foveal region), in addition to radially decreasing resolution in the periphery. These characteristics allow an animal to maintain visual awareness of its surroundings. They provide the animal with sufficient resolution (using the fovea) to identify objects of interest, while processing the imagery with enough speed to successfully react to most dangers. In contrast, most engineered visible or IR camera systems have a fixed spatial resolution that requires trade-offs between the resolution, field of view (FOV), and frame rate in order to process the resultant imagery in real time. Biological systems inspired some designers to develop visible spectrum cameras that have either a programmable or a fixed (requiring a pan/tilt assembly to control the gaze of the system) multiresolution capability. Nova Sensors developed a system that combines the benefits of foveal vision with the advantages of IR sensing.

Nova Sensors' MWIR VASI 320 x 256 pixel format camera system uses an indium antimonide detector array bonded to a novel readout integrated circuit that allows individual pixels to share their photocharge with any or all of their neighbors, creating a superpixel. A command controls the photocharge sharing and reconfigures the spatial resolution of the focal plane array (FPA) at the frame rate. This design allows high-resolution foveae to focus on ROIs while maintaining lower-resolution surveillance on the rest of their FOV. Since the photocharge sharing occurs on the FPA, the bandwidth required for the image data readout and processing significantly decreases in comparison to traditional IR imagers.

AFRL X-Ray Diagnostic Techniques Support Dynamic Cavity Formation Imaging Research

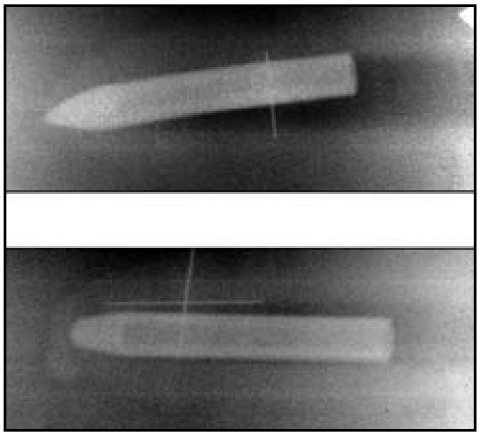
Payoff

AFRL's X-ray diagnostic techniques support scientific research regarding a penetrating munition's characteristics as it travels underground to the target. This knowledge increases weapon designers' understanding of the interactions that occur between the warhead and its target and also validates computer simulations for improving future warhead performance. X-ray diagnostic techniques under refinement at AFRL allow a fleeting glimpse of the cavity, a key indication of the penetration loading environment.

Without knowledge of a warhead's physical interactions, weapon designers are limited to judging a new warhead's performance by empirical trial-and-error measures such as penetration depth. The incorporation of proven theoretical penetration models into advanced computer simulations will optimize the warhead design process.

Accomplishment

Researchers at the Advanced Warhead Experimentation Facility, Eglin Air Force Base (Florida), recently captured X-ray images of laboratory-scale warheads as the weapons penetrated sand targets at high speeds (2,000-4,000 ft/sec). The investigated media revealed very complex reactions during penetration. This complexity resulted from the ability of the dry particles to move freely (in relation to each other) without the gluelike presence of moisture. The cavity around the high-speed projectile collapsed almost immediately after the projectile passed through it. The experiment series examined the effects of various conventional warhead nose shapes—sharply pointed ogive, blunted ogive, and spherical nose—in high-speed penetration of confined sand targets.



The experiment's preliminary results revealed that the penetration cavity is much smaller than expected. The portion of the warhead's nose making physical contact with the target media is small. Researchers are planning additional experiments both to increase the image database and to allow refinement of the X-ray diagnostic. When all unseen penetration phenomena are illuminated, researchers can assess the feasibility of futuristic design concepts.

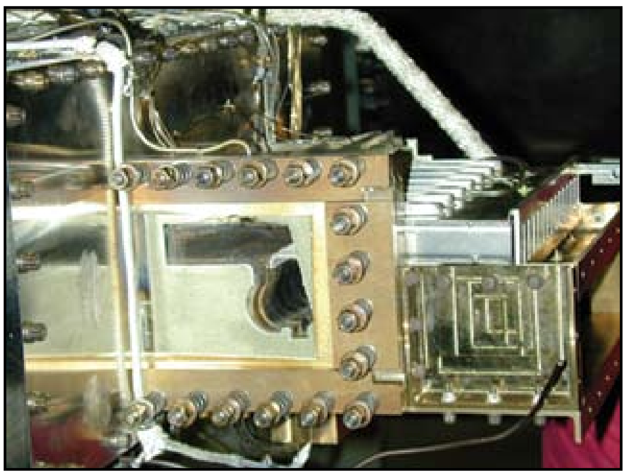
Background

Obtaining useful X-ray images has several challenges, including the ability of sand to absorb and scatter X-rays. To maintain image quality, researchers limited the target diameter to 6 in. To maximize the energy reaching the X-ray film, they kept the distance between the X-ray-generating head and the film as small as possible. Unfortunately, this small distance resulted in occasional flying fragment damage to the film and X-ray head. Researchers usually position the X-ray heads above and beside the expected flight path of the projectile to show orthogonal views. They use this technique to determine a projectile's pitch and yaw before target impact and to obtain a three-dimensional view of cavity formation during the penetration event. When multiple X-ray heads pulsed, however, shadow images appeared on the film as another by-product of the experiment's close quarters. Firing a single X-ray pulse mitigated the poor contrast and clutter caused by multiple shadow images. Despite its difficulties, the experiment series produced a dozen good pictures.

AFRL Completes Confined Recirculation Combustion Tests

Payoff

AFRL engineers successfully completed high-pressure combustor testing as part of a Small Business Innovation Research Phase I contract to develop confined recirculation combustion technology for afterburning applications. AFRL and Williams International developed the ultracompact combustor (UCC) rig under a previous joint effort.



Accomplishment

Scientists used the UCC rig for the tests, which they conducted in AFRL's High-Pressure Combustion Research Facility. This effort involved testing the combustor over a wide range of pressures and temperatures for performance and lean blowout. In addition, the team modified the rig for subsequent tests to study the effect of mixing combusted core flow with bypass air using a scalloped strut mixer. The mixer generates vortices that scientists use to accelerate the flow throughout the exhaust section. Williams International plans to introduce the resulting combustion and afterburning technologies to the AFRL Versatile Affordable Advanced Turbine Engine program.

Background

AFRL sets component goals for engine demonstrations to meet advanced Air Force (AF) missions. AFRL engineers explore and evaluate novel propulsion concepts that are critical to meet the AF's future needs. AFRL is enhancing component capabilities through the understanding and innovative use of chemistry, aerodynamics, heat transfer, materials, diagnostics, computational fluid dynamics, and design tools.

AFRL Testing Demonstrates Feasible Gas Turbine Engine Technology

Payoff

AFRL is conducting research on the ultracompact combustor (UCC), an essential part of an evolving technology to develop near-constant-temperature-cycle gas turbine engines. UCC technology can significantly reduce engine weight and size, while providing large amounts of power.

Accomplishment

High-pressure UCC tests conducted in AFRL's High-Pressure Combustion Research Facility demonstrated the viability of using UCC technology in advanced main combustor and interturbine burner systems. The UCC design integrates compressor and turbine features that will enable a shorter and less complex gas turbine engine. Experimental results from UCC testing at elevated pressure indicated that the combustion system operates at 95%-99% efficiency over an increased operating range compared to conventional gas turbine combustion systems burning JP-8+100 fuels.

Background

AFRL conducts basic and applied research to enhance the technical capability of turbopropulsion systems. UCC design, development, and testing efforts are part of AFRL's interdisciplinary research plans to explore novel and innovative concepts critical to meeting future Air Force operational requirements. AFRL also has the objective to transfer new technology to other government and commercial agencies and thus maintains awareness regarding national and international gas turbine engine development organizations.

AFRL Opens Distributed Heterogeneous Simulation Laboratory

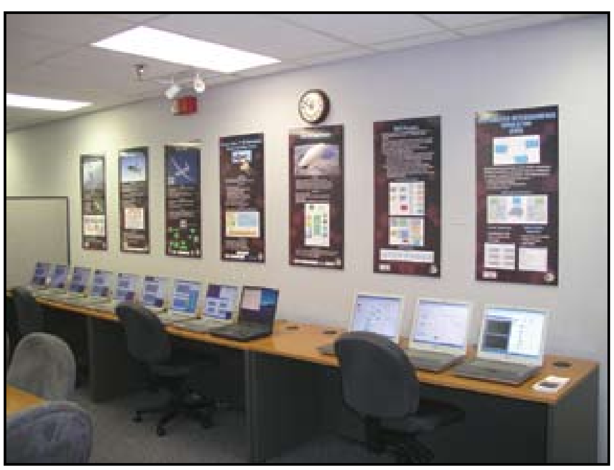
Payoff

AFRL opened the Distributed Heterogeneous Simulation (DHS) Laboratory to enable faster and more detailed simulation of large-scale dynamic systems. The DHS Laboratory takes advantage of advanced techniques developed with industry partner PC Krause and Associates under Air Force (AF) Small Business Innovation Research Phase I and II projects. Essentially, the DHS Laboratory's various computer interconnections provide an inexpensive, high-speed computational capability that enhances the design, operation, and security of large-scale dynamic systems.

Accomplishment

Researchers use the DHS Laboratory to simulate and analyze numerous systems of interest to the AF. This research supports the integration of propulsion, power, thermal, avionics, sensor, and directed energy weapon subsystems at an unsurpassed level of detail. For example, Global Hawk program researchers plan to investigate integrated propulsion, power, and electrical load dynamic performance, including advanced sensor suites such as the Multiplatform Radar Technology Insertion program for expanded available payload during high-altitude flight.

In addition, researchers supporting the F-35 Joint Strike Fighter program are using the facility to integrate proprietary contractor models written in different languages, allowing them to investigate and mitigate adverse component interactions. The DHS Laboratory also supports efforts such as the F-16 Integrated Cooling and Power System, Airborne Active Denial, High-Altitude Airship, and Supersonic Combustion Ramjet programs.



Background

Complex systems, including commercial/military aircraft, unmanned air vehicles, ships, land vehicles, and advanced weapons systems, involve a broad spectrum of technologies and interactive subsystems that must interact synergistically to achieve mission goals. Thus, the design of these complex, large-scale systems requires collaboration among geographically dispersed groups and design teams based within private companies, government laboratories, and/or universities. The focus of these groups is often limited to specific subsystems or areas of expertise; however, the interdependencies existing between these subsystems increase the importance of establishing detailed, end-to-end system simulations for the design, analysis, and optimization of complex, large-scale systems.

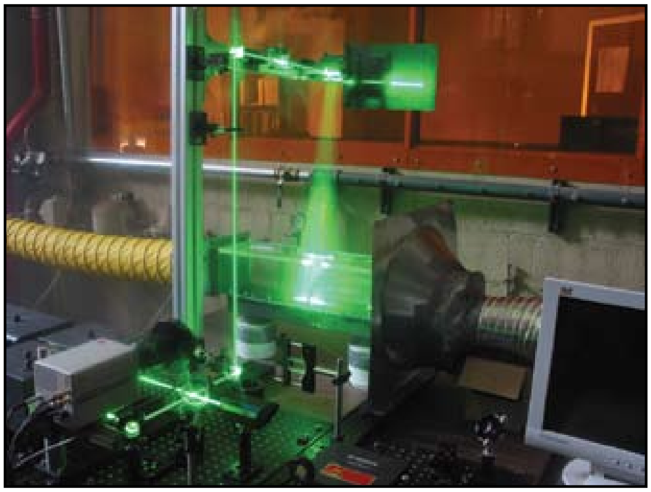
AFRL Laser Diagnostic Tool Assists Next-Generation Engine Development

Payoff

AFRL and Rolls-Royce engineers used a laser diagnostic tool—the Particle Image Velocimetry (PIV) measurement technique—to collect critical validation data for computer design codes that will drive the next generation of engine development. AFRL's goal is to transfer advanced technology to industry, government agencies, and military services.

Accomplishment

The engineers used PIV techniques to complete a study of jet penetration into cross-flow airstreams. They successfully tested six configurations of varied cross- and jet-flow rates with two different plate-hole geometries, collecting data for each configuration at multiple planes of view. The team used consecutive images from a high-speed camera to correlate particles seeded into the cross- and jet-flow fields. To determine the related velocities, they measured the travel distance of the seed particles in a given time frame, and they acquired three PIV datasets at each condition. The engineers collected spreadsheets of test parameters and run conditions from a data acquisition system that documented each test. Test results indicated a positive correlation between the PIV data and expected results. The team also noted another achievement: visualization of jet penetration and mixing.



Background

AFRL is studying PIV technology and its applications to engine development by conducting basic and applied research to enhance the development of turbopropulsion systems. Laboratory researchers are also establishing existing and theoretical component performance and durability capability through the evaluation and integration of aerodynamics, heat transfer, material application, and other design factors.

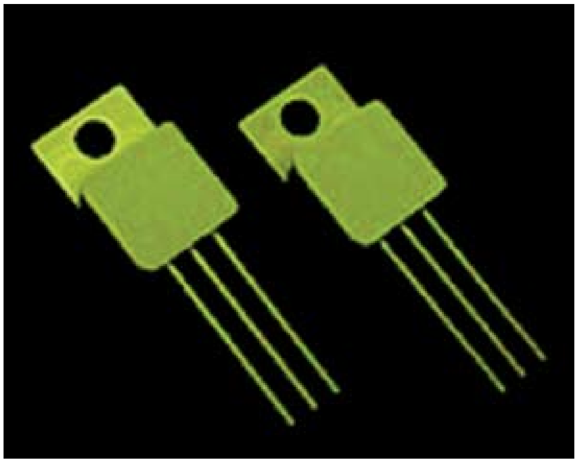
AFRL Transistor Technology Results in Commercial Product Development

Payoff

AFRL developed junction field-effect transistor (JFET) switching devices for use in high-temperature operational environments. AFRL received requests from potential commercial users to evaluate JFET applications ranging from drill head motors for oil exploration to various aerospace uses.

Accomplishment

AFRL and industry partner SemiSouth Laboratories, Inc., achieved a milestone in transistor technology and product development. They developed switching devices known as Harsh-Environment, Low-Loss Field-Effect Transistors (HEL2FET™), which offer electrical component manufacturers a line of switching devices with potential applications for motor drives, converters/inverters, and other electrical power equipment that has high-temperature operational requirements. The Air Force also has several power system requirements that this technology can satisfy, including electromechanical actuator motor drives to operate flight control surfaces, motor drives for fuel pumps, power modules, solid-state circuit breakers, radiation-tolerant power management and distribution components for space platforms, and integrated radar power supplies.



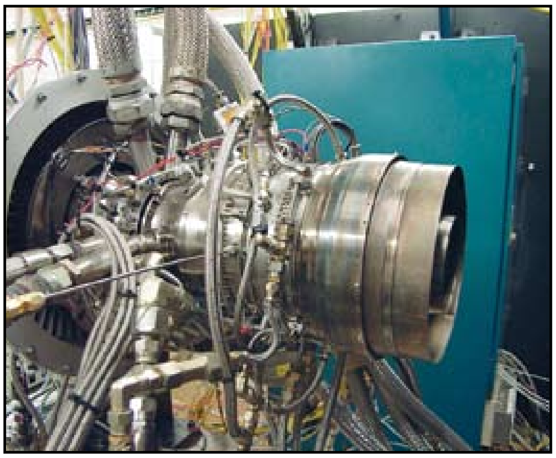
Background

In conducting power-related research, development, and technology transition for the military services, Department of Defense agencies, and industry, AFRL provides the essential foundation for technology development to support military systems acquisition and commercial applications.

AFRL's Turbine Engine Testing Reduces Engine SFC

Payoff

Engineers tested the XTC87/2 demonstrator engine as part of the Integrated High-Performance Turbine Engine Technology (IHPTET) program aimed at improving turbine engine technology and capabilities. The IHPTET program shows significant payoffs in durability, mission reliability, and affordability. Additionally, IHPTET design practices will lead to longer inspection intervals and lower maintenance costs. The program also provides the basis for continued preeminence in civil aircraft engine development, since the technology is almost entirely dual-use in nature.



Accomplishment

AFRL engineers completed XTC87/2 Joint Expendable Turbine Engine Concepts (JETEC) demonstrator engine testing. As part of the IHPTET program, the JETEC effort focuses on development of expendable and limited-life-use engines for applications such as nonrecoverable missiles and unmanned air vehicles. The successful XTC87/2 demonstrator test effort advances state-of-the-art turbine engine technology by achieving a 23% reduction in the engine's specific fuel consumption (SFC), resulting in increased range and mission capability. This achievement represents a significant step in meeting SFC-related goals. The successful testing also demonstrated the steady-state performance, durability, and robustness of uncooled ceramic turbine blades at temperatures as much as 870°F above the IHPTET baseline.

Background

The IHPTET program centers on an aggressive technology plan to overcome barriers in the development of affordable, advanced, high-performance turbine engines. IHPTET is producing revolutionary advancements in turbine engine technologies due to the synergistic effect of combining advanced material development, innovative structural design, and improved aerothermodynamics.

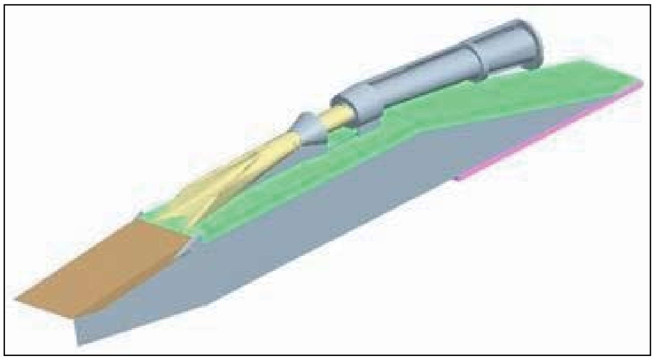
Elliptical Combustor Benefits Scramjet Performance

Payoff

AFRL engineers completed a study on the elliptical combustor supersonic combustion ramjet (scramjet), which provides performance benefits over conventional, rectangular scramjet engines for cruise missile applications and hypersonic reconnaissance and strike aircraft. The study assessed the integrated performance of the elliptical combustor scramjet (ECS) after its integration into a baseline missile airframe. The study team applied and modified design tools to make performance and operability enhancements to the existing ECS flow path for low-Mach-number and on-design operation.

Accomplishment

Engineers performed the study, entitled "Elliptical Combustor," under AFRL's Robust Scramjet program. In the study, they modified a National Aeronautics and Space Administration hydrogen-fueled, nonrectangular scramjet design to operate on a hydrocarbon fuel. AFRL integrated the engine into a hypersonic missile airframe to determine performance of the integrated engine/vehicle design. This effort evaluated the viability of the integrated nonrectangular hypersonic air-breathing propulsion system, or the ECS.



Background

AFRL's program demonstrates the operability, performance, and structural durability of liquid hydrocarbon scramjets. The near-term application of this technology is a long-range hypersonic cruise missile that is logistically supportable in a combat environment and can defeat time-sensitive, as well as hard and deeply buried targets. Eventually, the scramjet technology will enable a Mach 8-10 strike/reconnaissance aircraft and affordable, on-demand space access with aircraft-like operations.

AFRL Validates New Smoke Measurement System

Payoff

AFRL successfully validated its Turbine Engine Smoke Measurement System through comparison testing with similar smoke measurement systems. Scientists field-tested the system at various throttle settings to measure turbine engine emissions. The validation of the Turbine Engine Smoke Measurement System supports pollutant emissions test practices that AFRL scientists use both for development purposes and for Joint Strike Fighter (JSF) full-engine emissions testing.

Accomplishment

AFRL, the Arnold Engineering Development Center, Middle Tennessee State University, the University of Dayton Research Institute, and program support contractors jointly conducted this turbine engine emissions testing. Scientists obtained smoke samples from a CFM56 combustor, which operates at AFRL's High-Pressure Combustion Research Facility and in J-12 aircraft engine field tests at Middle Tennessee State University, Murfreesboro, Tennessee. Quantification of gaseous and particle emissions may influence the placement of the JSF throughout the US. Levels of emitted engine particulates may restrict the JSF aircraft from some locations due to environmental considerations.

Background

AFRL sets component goals for engine demonstrations to meet specific advanced Air Force missions. The laboratory explores and evaluates novel propulsion concepts critical to meeting future needs, while enhancing component capabilities through the understanding and innovative use of chemistry, aerodynamics, heat transfer, materials, diagnostics, computational fluid dynamics, and design tools.

AFRL Research Supports the Development of High-Temperature Superconducting Technology

Payoff

AFRL demonstrated that minute additions (<1%) of certain divalent rare earth elements can improve the properties of yttrium barium copper oxide (YBCO) superconducting films. Scientists discovered that when small quantities of rare earth elements are well-dispersed throughout the YBCO superconductor, they act as nanopinning centers and improve the critical current.

Accomplishment

The superconductor community previously considered smaller-percentage additions of rare earth elements to have little impact on the superconducting properties of rare earth barium cuprate superconductors. Therefore, they used larger-percentage additions (10%, 20%, and so on). The elements cerium (Ce), terbium (Tb), and praseodymium (Pr) were detrimental as large additions; consequently, scientists ignored these elements. However, AFRL experts hypothesized that the divalent rare earth elements' detrimental nature has potential uses. They demonstrated the validity of this hypothesis (for Ce and Tb) for higher in-field critical currents. AFRL is optimizing the result to determine this method's maximum possible improvement. The laboratory will soon begin testing on Pr-doped samples.

Background

AFRL conducts research in advanced high-power systems. This research supports the development of high-temperature superconducting technology, which is an essential element for the design and development of future advanced, compact, high-power generator coils and magnets for aerospace applications such as directed energy weapons.

AFRL Research Team Completes Solar Thermionic Converter Testing

Payoff

The Air Force needs a reliable solar energy conversion system for use on spacecraft that require electrical power for extended periods of time. Cylindrical Inverted Converter technology is critical to helping meet these requirements.

Accomplishment

A joint AFRL/National Aeronautics and Space Administration (NASA)/General Atomics (San Diego, California) research team successfully ignited a solar-heated thermionic converter, which converts heat energy to electrical energy. During AFRL's testing, the thermionic converter generated 160 A at 0.2 V (over 30 W of electrical power)—the most electrical power output ever achieved from a single solar-heated thermionic converter.

Background

This very successful "on-sun" demonstration of Cylindrical Inverted Converter technology is especially important to AFRL's High-Power, Advanced Low Mass (HPALM) program, which requires a solar energy conversion system for use with spacecraft.

The HPALM concept involves the use of an inflatable solar concentrator to focus solar energy onto a thermionic converter. AFRL's research team conducted this test at the NASA Marshall Space Flight Center's Solar Thermionics Ground Test Facility in Huntsville, Alabama.

New Algorithms Improve GPS Signal Acquisition

Payoff

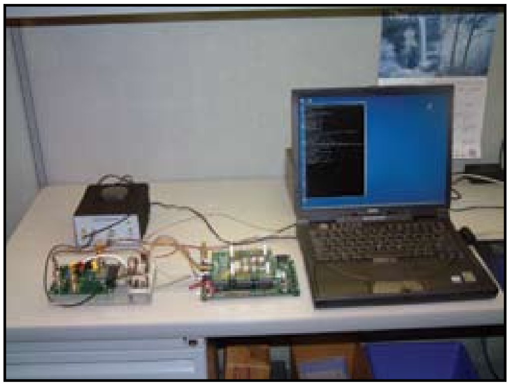
Scientists devised a new method to more efficiently correlate the Global Positioning System (GPS) signal acquisition. This new software approach will greatly accelerate the code and frequency acquisition of the GPS receiver.

Accomplishment

AFRL sensors scientists improved the GPS satellite signal acquisition method and device. They reduced the number of operations in the block correlation used to determine Doppler frequency and GPS codes. Reducing the number of operations in block correlations increases acquisition speed and reduces energy requirements.

Background

GPS is a critical enabler for many commercial and military systems, but GPS satellite signals are easily jammed or lost due to terrain masking, maneuvering, or multipathing. A software receiver implementation offers significant advantages to the user in terms of system programmability and robustness. The computational complexity of receiver functions must be reduced in order for receiver functions to be implemented affordably in software.



Acquisition of the GPS satellite signal is a key receiver function that is computationally complex and prohibitively expensive to implement in real-time software based on current technology. This invention reduces the complexity of GPS code acquisition, allowing the acquisition function to be implemented in the software.

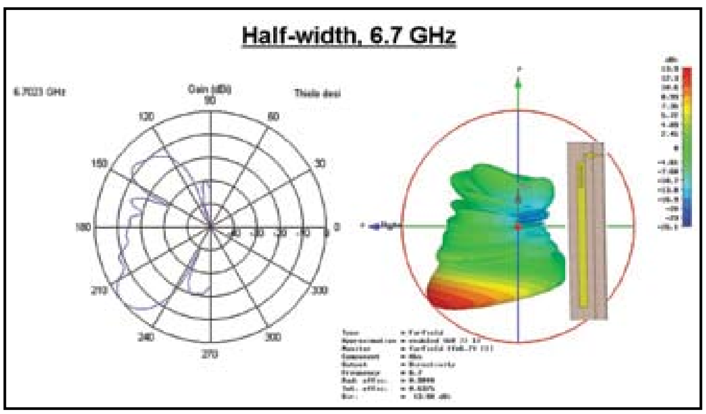
To acquire the GPS signal, the received signal must be correlated with a replica of the code division multiple access code generated in the receiver. Traditional correlation methods use continuous sliding multiplication and addition to align the phase of the signal and replica code. The approach taken for this invention down-converts the sampled data to base band, partitions the sampled data into small blocks, performs frequency domain correlation in block level, and coherently combines the block-level results through fast Fourier transform, greatly reducing the total computation time.

AFRL Designs and Fabricates a Reduced-Width Leaky Wave Antenna

Payoff

AFRL successfully designed, fabricated, and tested a reduced-width leaky wave antenna, which is a microstrip antenna that utilizes the first higher-order mode rather than the usual microstrip transmission line mode. This device is inexpensive and more reliable than existing technology. The leaky wave phenomenon demonstrates significant bandwidth improvement over existing microstrip antenna configurations, including the popular patch antenna.

Accomplishment



Previous designs required the strip width to be a half wavelength, whereas the reduced-width antenna requires a strip width of just a quarter wavelength. The AFRL microstrip's low-profile design is extremely thin, lightweight, inexpensive, and easy to fabricate.

The antenna is a traveling wave antenna, and its radiation can be frequency-scanned in the elevation plane containing the long dimension of the antenna. It is a guiding structure wherein guided waves readily travel, but excite the leaky wave only under certain microstrip conditions. With proper design, these leaky waves account for the radiation into free space and form a narrow beam in the elevation plane. These antennas can be flush-mounted onto an aircraft's exterior for avionic and space-based applications. In today's environment, this class of antenna is particularly applicable for small unmanned air vehicles.

Background

In conventional rotating antennas, a heavy antenna rotating mechanism is necessary for scanning beams but is too expensive and slow. Thus, the weight and size needed for adequate performance renders such an antenna impractical in airborne- and space-based systems. Leaky wave antennas have many advantages in microwave and millimeter-wave applications. To avoid conduction loss and minimize complexity in fabricating microwave and millimeter-wave circuits, waveguides usually entail open structures such as a microstrip. Because the leaky wave antenna is derived directly from the microstrip transmission line, integration with a source and other waveguide components is easy. This integration reduces the size, weight, and cost of the antenna system.

AFRL Reduces the Packaging Cost for Space Applications

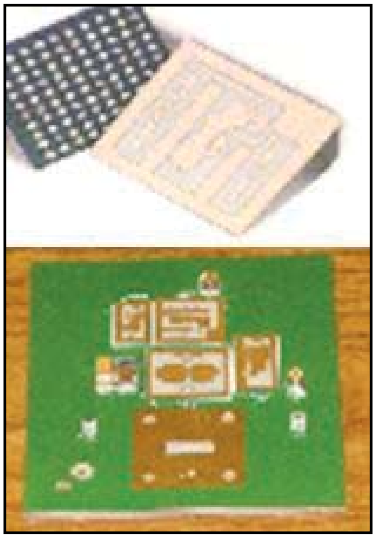
Payoff

AFRL and Northrop Grumman collaborated on the Advanced Low-Cost Packaging for Space (ALPS) program, a Dual-Use Science and Technology program for reducing packaging costs for space applications by 90%. ALPS technologies enable the lightweight, low-profile, mixed-signal assemblies that space and avionics array antennas require. The ball grid array (BGA) interconnect establishes a high-density, low-parasitic, high-performance product, reducing production costs by a factor of 10 and dramatically increasing frequency capabilities.

Accomplishment

ALPS specifically addressed nonhermetic packaging; radio frequency (RF) interconnects (multilayer printed wiring boards with integrated waveguide launches); chip carriers based on beryllium oxide, alumina, and multilayer duroid substrates (buried components in boards and modules); and automated assembly of module and board-level systems. The AFRL/Northrop Grumman team successfully fabricated, tested, and produced two demonstration vehicles using the packaging techniques.

One demonstration included a nonhermetic set of BGA modules with a multilayer board for interconnection to form a 20 GHz transmitter for use in a military space application such as a space-based radar or extremely high frequency communication satellite. In the second demonstration, the team implemented a 30-to-8 GHz down-converter module as a soft-board multichip module to target commercial satellite communications applications.



Background

Space surveillance and communications applications are a major Air Force focus. Successful electronic systems for these applications are critically dependent upon effective and efficient packaging.

Prior to the ALPS program, space modules consisted of machined metal composite housings with chips, interconnecting alumina substrates, and alumina substrate filters. Engineers created RF connections via coaxial connectors or waveguide ports built into housings. They sealed the completed assemblies with flat covers by laser welding and conducted the standard postseal screening for military space. Engineers established RF interconnections (over a few GHz) using coaxial cable or waveguide. By reducing part count and assembly labor and employing inexpensive materials, the ALPS technology generates significant savings in RF-intensive applications.

DARPA Program Incorporates Novel AFRL Microstrip Electro-Optic Modulator

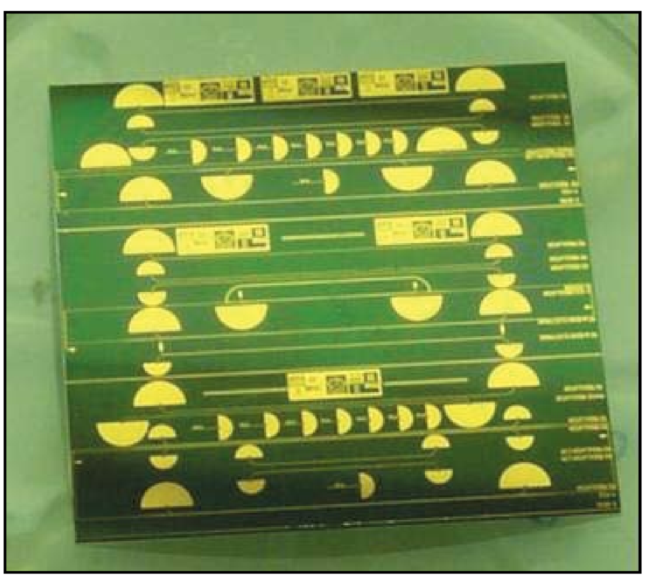
Payoff

AFRL and the University of Southern California successfully designed, fabricated, and demonstrated a polymer electro-optic (EO) modulator with a 40 GHz bandwidth. The team transitioned the modulator design to the Army and Navy for use as the standard material test bed for the program. Increased bandwidth, efficiency and reduced size will greatly improve layered sensing functions, enabling fewer antennas performing multiple functions for both small unmanned air vehicles and space-based applications.

Accomplishment

The demonstration was a key milestone for the Defense Advanced Research Project Agency's (DARPA) Super Molecular Photonics (MORPH) program. The MORPH program is an exploratory effort that successfully demonstrated the ability of engineered molecular nanosystems to achieve spectacular increases in optical nonlinearity. DARPA created this synergistic opportunity by linking the three services together on a team to jointly transition this new technology to the warfighter.

Researchers validated material performance in hardened devices suitable for commercialization and insertion into military systems. The interferometric modulator was the first modulator to use the microstrip-to-coplanar waveguide transition in conjunction with an EO modulator. These structures increase the accuracy and convenience of high-speed testing of unpackaged devices.



Background

Shrinking the platform size means room for fewer antennas, requiring the onboard antennas to perform multiple functions. To meet the resulting need for broad-bandwidth (1-100 GHz) antennas, scientists will employ technology enabled by analog photonic radio frequency (RF) links. Size, weight, and bandwidth advantages, as well as protection from electromagnetic interference, are some of the improvements photonic links offer over standard coaxial-cable-based links.

The telecommunications industry's needs are based in the digital domain and will not fulfill current and future Department of Defense analog requirements. The MORPH program aims to increase modulation efficiency to all photonic links applicable to RF antenna support. Improved efficiency is critical for space applications, where prime power is limited. The microwave-to-coplanar transition, in conjunction with an EO modulation, will prove an invaluable tool in the program's development.

AFRL Demonstrates Multisensor Data Exploitation Capability

Payoff

The military uses sensors for intelligence, surveillance, and reconnaissance (ISR) in many systems and thus requires a consistent means for groups or organizations to exchange data acquired from multiple, diverse sensor types. Standardizing the sensor exchange language permits the reuse of sensor tools and the ability to share and communicate sensor data among various military systems.

Accomplishment

Sensor data systems are difficult to bring together, and because multiple data formats exist, data fusion is more difficult still. Traditional, file-based sensor standards are not designed for live streaming of raw sensor data. Further, the limitations associated with these file-based formats generate geolocation object/target data inaccuracies. To overcome these limitations, AFRL and IRIS Corporation (Ann Arbor, Michigan) engineers developed the Transducer Markup Language (TML), an approach both for standardizing sensor data and critical metadata for capture, transport, archiving, and processing, and for enabling sensor data fusion efforts.

AFRL engineers demonstrated TML's capability to read and interpret data from six different sensors (weather station, motion sensor, camera, Global Positioning System, inertial measurement unit, and digital compass)—all producing their own data formats, converted to TML and read in TML at a ground station computer for display. As a result of these demonstrations, the National Geospatial-Intelligence Agency proposed and supported a Small Business Innovation Research (SBIR) Phase III effort designed to bring TML to a level where transition is possible. The SBIR Phase III contract will support transition strategies and risk reduction activities, leading both to operational demonstrations and to participation in the Multiservice Advanced Sensors to Counter Obscured Targets technology demonstration with US Special Operations Command and US Army Intelligence and Security Command.

Background

Previous sensor systems required a separate interpretation of each individual sensor's output. When merging different data sources, the custom applications built for each individual sensor system sometimes resulted in unnecessary errors.

TML normalizes sensor data and metadata from a user's perspective. Once connected to a network, a TML sensor system permits authorized users to exchange comprehensible data from that system without building proprietary interfaces to other processors. A fully enabled TML processor will recognize and process simple sensors (e.g., temperature sensors) as well as complex sensors (e.g., synthetic aperture radar).

Commercial uses include manufacturing, medical, weather, environmental, and geophysical monitoring—virtually any application involving a network of sensors requiring interoperability. TML use will thus benefit sensors used for air, space, surface, and underwater ISR; weather, environmental, and geophysical monitoring; airspace control; biomedical monitoring; industrial process control; and modeling and simulation.

TML has tremendous implications for facilitating sensor system interoperability and is the key ingredient for a global sensor network. In its basic form, TML enables "what," "when," and "where" descriptions for each individual digital sensor sample, with very little overhead.

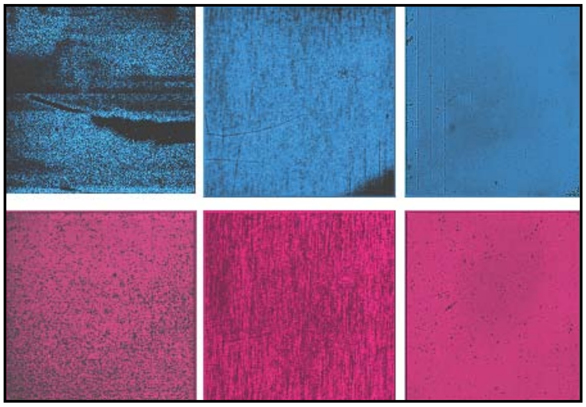
Improvements in Dualband LWIR FPAs

Payoff

AFRL manages a Rockwell Scientific Company effort known as the Advanced Long-Wave Infrared Two-Color (ALIRT) Focal Plane Array (FPA) program, which researches dualband, mercury (Hg) cadmium (Cd) telluride (Te) wafers grown with molecular beam epitaxy. Dualband FPAs provide greater discrimination capability and reduce the false alarm rate associated with viewing scenes of various target types. They image targets simultaneously in two infrared bandpasses, and these images are perfectly registered on a pixel-by-pixel basis. Targets, decoys, and background clutter have time-varying signals, with variation due to intrinsic target fluctuations and altering target range.

Accomplishment

During the study, scientists overcame several performance issues that had previously limited dualband capability. Paradoxically, the HgCdTe's longer wavelength response represented the greatest challenge, since the narrower energy band gap renders the material more sensitive to its crystalline imperfections. However, as a result of large Department of Defense investments in long-wave infrared (LWIR) HgCdTe for the Space Tracking and Surveillance System, the longer wave band (Band 2) initially outperformed the shorter wave band (Band 1) in terms of improved dark current and diode current-voltage characteristics.



ALIRT Band 1 performance was initially compromised by the deep etching of the material required at each pixel site to establish electrical contact with that pixel's Band 1 diode, as well as the Band 1-to-Band 2 transition architecture. The combined efforts of the ALIRT program and the Army Night Vision and Electronic Sensors Directorate program for dualband flexible manufacturing—with its emphasis on midwave and long-wave dualband capability—solved the Band 1 problem.

Background

ALIRT FPAs comprise both the detector array and a cryogenic detector multiplexer fabricated in a commercial silicon foundry. Both the detector array and the multiplexer are based on a specific dualband design. The HgCdTe detector material is grown with molecular beam epitaxy, providing precise control of compositional (relative amounts of Hg and Cd) and doping profiles. The approach is ideal for dualband pixel architectures, where separate signal photocurrents must be generated and outputted from separated vertical layers in each pixel.

AFRL Develops Support for MCT on Silicon Technology

Payoff

AFRL obtained support for the development of silicon (Si)-based composite substrates for mercury-cadmium-telluride (MCT) infrared (IR) detectors. MCT IR detectors are widely used for Air Force and Missile Defense Agency (MDA) missions to support US national defense.

Accomplishment

Realizing the advantages of using Si-based composite substrates for the growth of MCT IR detector arrays, AFRL researchers sought a supplier with expertise in MCT and substrates to provide the Si-based composite substrates required for this technology. EPIR Technologies, Inc., is a small business with significant activity in this area; the company received at least 12 Small Business Innovation Research (SBIR) contracts in 2005, the majority of which involved IR detectors. AFRL and EPIR expect to establish a merchant supplier of Si-based alternative substrates and MCT on Si technology.

Background

Despite superior performance, MCT detector arrays have a serious drawback associated with their cadmium (Cd)-zinc (Zn)- tellurium (Te) substrates. CdZnTe substrates are brittle and not available in sizes greater than 2 in. in diameter. Additionally, they are very expensive and lack a US commercial supplier. Thus, fabrication of large megapixel arrays of MCT IR detectors is not a simple endeavor.

AFRL is largely responsible for this technology development and thus advocated it to the MDA and throughout the laboratory. To facilitate this effort, AFRL researchers wrote SBIR topics, ensured associated contracts were awarded to develop MCT on Si, and obtained external funding for an enhancement program. They acquired this funding from the Army Research Laboratory and secured matching funds from the Air Force SBIR Program Office. AFRL also obtained MDA funding to develop MCT on Si focal plane arrays.

Space Electronics Analysis, Modeling, and Simulation Center Realizing New Paradigms in Space Microelectronics Research and Development

Payoff

AFRL's Space Electronics Analysis, Modeling, and Simulation (SEAMS) Center is a unique resource for sustaining and improving the Department of Defense's (DoD) microelectronics infrastructure. The SEAMS Center addresses technological and resource-related barriers in the design phase of procurement rather than during the manufacturing or test and evaluation phase. Cost savings occur with the ability to transfer, evaluate, and merge intellectual property. The SEAMS Center provides research results and otherwise enables programs by serving as a hub for the exploitation of electronic design automation tools and integrated circuit fabrication.

Accomplishment

The SEAMS Center works to address DoD space mission requirements, as well as to streamline the design process for space microelectronics by attracting top-quality universities and leading commercial companies. The center is developing integrated design tool suites that specifically address radiation hardening issues. Application of these radiation hardening techniques in the design phase of a research and development program allows the use of lower-cost commercial fabrication sources. The facility also serves as a repository for intellectual property that the government owns or contractors donate for future programs. The combination of these methodologies, as well as new attitudes towards space microelectronics research and development, will reduce development time considerably and allow procurement of high-end integrated circuits at reduced costs.

Background

The SEAMS Center addresses the specific problems of developing integrated circuit electronics for the Air Force and DoD. The center focuses primarily on exploiting new opportunities in the areas of advanced microelectronic circuit architectures, electronic design automation tools, integrated circuit fabrication foundry access, and reconfigurable technologies. The center develops and evaluates intellectual property; it also ensures sustainment of the radiation-hardened electronics community through small-business incubation and mentoring programs.

One of the center's efforts is the development of radiation-hardened, analog-to-digital converters that are applicable to a broad-based set of user requirements, including the Global Positioning System. These converters are representative of highly integrated, mixed-signal components that defense systems employ to convert a sensor's analog signals to a digital representation for processing. Electronic design automation tool developments are occurring with commercial industry leader Mentor Graphics Corporation, as well as through Defense Advanced Research Projects Agency-sponsored small business research. These efforts are providing advanced modeling, simulation, optimization, design, and verification in an integrated design flow. The government/industry/university design team is leveraging innovative techniques conceived at the Center for Design of Analog-Digital Integrated Circuits for access to competitively priced commercial fabrication sources and time-saving software to demonstrate an efficient methodology for producing advanced radiation-hardened microelectronics.

Technology Transfer

Page

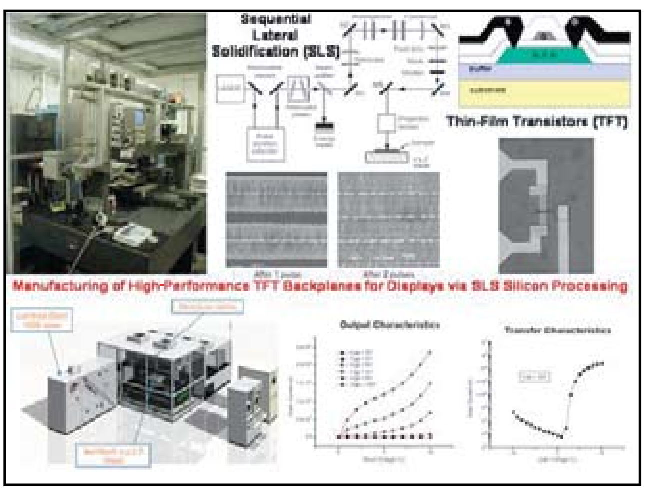
AFRL and DARPA Transfer Advanced Manufacturing Technology to Display Industry

Payoff

AFRL managed Defense Advanced Research Projects Agency (DARPA)-funded efforts over several years to invent sequential lateral solidification (SLS) silicon process technology. The resulting technology became the foundation of several new $2 billion industrial facilities to manufacture large-area high-performance flat panel displays.

Accomplishment

AFRL transferred SLS silicon process technology to industry for the high-volume manufacture of active matrix (AM) electronic backplanes that control image generation in flat panel displays. SLS enables the use of high-performance silicon circuits that have 100 times fewer hardwired leads compared to current, amorphous silicon technology, thereby removing a key failure point in fielded products. These SLS circuits also reduce the power and volume required for military and commercial displays. Essentially, the SLS technology paves the way for computer hardware to merge with the associated display device.



Background

AFRL teamed with DARPA to create, develop, and transfer the technology to fabricate electronic backplanes for displays via SLS processing techniques on glass and plastic substrates. The laboratory-led effort developed high-performance polysilicon thin-film transistor backplane circuits via research funded at the Sarnoff Corporation (formerly RCA Labs) from 1986 to 1990. The process, however, has been limited to prohibitively expensive high-temperature substrates such as quartz; hence, the process is restricted to small AM liquid crystal display applications, including 3-inch flight instruments and miniature projection imagers. The improved silicon circuits were previously unavailable for large-area displays, which have gained popularity in cockpits and crewstations. DARPA funded a multiyear effort at Columbia University to develop SLS; develop two-shot, directional, and single-crystal SLS techniques for display manufacturing on low-temperature substrates; and transfer results to industrial manufacturing.

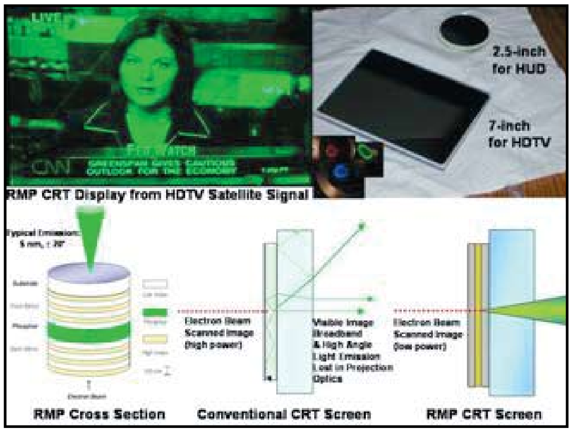
AFRL-Sponsored Technology Dramatically Improves CRT Power Efficiency and Resolution

Payoff

In terms of units produced, the cathode ray tube (CRT) is still the world's main display technology. Particular CRT advancements allow industry to compete with the performance of advanced flat panel displays used in projection television and medical imaging markets. Advanced CRTs also create production capacity and affordability for the military.

Accomplishment

As part of a three-phase Small Business Innovation Research effort, AFRL and its industry partner created, developed, and transitioned resonant microcavity phosphor (RMP)-CRT technology to industry. The RMP-CRT dramatically improves the traditional CRT's power efficiency and resolution (spatial, grayscale, and color), yet leverages mainstream drive electronics from vacuum tube and digital electronics industries. The RMP-CRT's pure primary colors enable an extremely large color gamut—more than double the range of standard television and computer monitors. The unique spatial and spectral characteristics of the light emitted by an RMP anode screen are ideal for projection light engines.



Background

AFRL initiated an innovative electro-optics technology program that ultimately resulted in RMP invention, development, and prototypes. A commercial digital high-definition television (HDTV) manufacturer assisted in transferring the RMP technology to industry. The team demonstrated full HDTV video performance at 1,080 lines progressively scanned. The transfer makes possible other near-term commercial applications, such as high-resolution wall map displays and laser replacements in medical analytical equipment and public jumbo screens.

After demonstrating the first prototype, AFRL transitioned the digital head-up display (HUD) to the military. An internal research and development initiative at CMC Electronics accomplished this transition. For the HUD application, RMP-CRTs address reliability issues in legacy fleets and provide a route to achieving color and higher resolution.

AFRL Establishes Partnership With Wright State University

Payoff

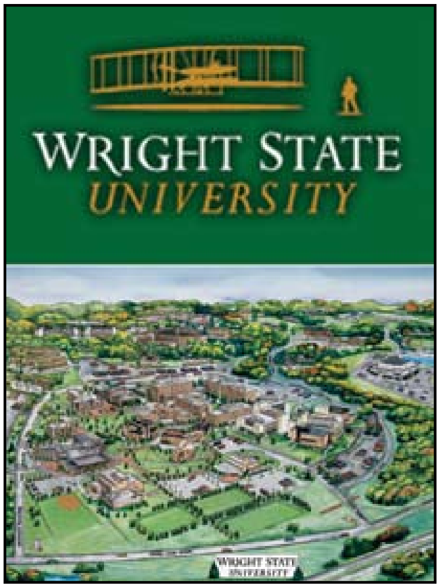
AFRL and Wright State University (WSU) collaborated to establish the Center of Excellence for Cell Dynamics and Engineering. The center, located on the WSU campus, will rely on the Wright Brothers Institute to serve as its intermediary partner with AFRL. Research conducted at the center will provide revolutionary products and capabilities for national defense and the general public.

Accomplishment

The innovative research program to be pursued at the center originates from the observation that living cells have amazing capabilities to self-organize, adapt, self-repair, and evolve new functions. A cell monitors its local environment using an array of biomolecular sensors and uses the information gathered to ensure its survival when normal environmental conditions are compromised.

Proposed applications for the new technology, referred to as cell-like entities, include sensing physical, chemical, and biological changes in the environment; monitoring human health and fatigue; detecting chemical and biological warfare agents; and controlling microelectromechanical devices. The objective is not only to detect environmental signals, but to respond to them as well.

Background



Dr. John Frazier is an AFRL senior scientist of quantitative toxicology and a WSU associate professor in the Department of Pharmacology and Toxicology. He is the lead scientist for the AFRL research effort in this biotechnology area. Collaboration is key to the success of this cutting-edge technology. In addition to its new Center of Excellence in the WSU School of Medicine, the AFRL research group has important research collaborations with the WSU Department of Physics, the WSU Department of Computer Science, and the Ohio Supercomputer Center.

The efforts of local congressmen and the Dayton Development Coalition enabled the center's establishment at WSU. This research is also made possible in part through Ohio's Third Frontier Project, which supports a regional partnership known as the Genome Research Infrastructure Partnership. Other institutions that participate in the partnership include the University of Cincinnati's Genome Research Institute, Procter & Gamble Pharmaceuticals, and the Cincinnati Children's Hospital Foundation.

Test Pilots Wear AFRL Technology in Space and Capture $10 million "X Prize"

Payoff

The potential uses for customizable hearing protection are infinite. AFRL developed advanced hearing protection technology to aid the military, the private sector, entertainers, and firefighters. AFRL's advanced hearing protection can benefit users who require advanced on-the-job hearing protection and superior audio communications capabilities.

Accomplishment

AFRL and Westone Laboratories, Inc., delivered clear audio and hearing protection for pilot use at altitudes exceeding 367,000 ft. Test pilots Mr. Brian Binnie and Mr. Michael Melvill wore the Attenuating Custom Communications Earphone System (ACCES™), AFRL's advanced hearing protection technology, during back-to-back SpaceShipOne flights. As a result of their efforts, both men earned astronaut status as the only civilians to reach space in a privately built and funded vehicle and thereby captured the $10 million X Prize, a cash award intended to encourage entrepreneurial space travel.

ACCES decreases the intensity of sound that reaches the eardrum, while enabling audio intelligibility. With its breakthrough technology, ACCES blocks ambient noise and improves audio communications intelligibility—even in environments where hearing is an immense challenge.

Unlike conventional headset technology, ACCES delivers communication through a hearing protection earphone customized for each user. Made from impressions of the user's ear canal, the earphone has a high-fidelity miniature receiver deeply embedded within each ACCES earpiece. Combined with the embedded receiver, ACCES permits a high-fidelity speech signal from the miniature loudspeaker.

Background

Mr. Binnie reached 367,442 ft, an altitude beyond the internationally recognized space boundary. He thus secured the second qualifying flight of SpaceShipOne and the $10 million X Prize. One week earlier, Mr. Melvill piloted the first qualifying X Prize flight at 337,569 ft altitude. Mr. Melvill also wore ACCES during a test run of SpaceShipOne, which at 328,451 ft altitude, nearly reached space.

AFRL Transfers Human Performance Modeling Technology to F-15E Mission Training Center

Payoff

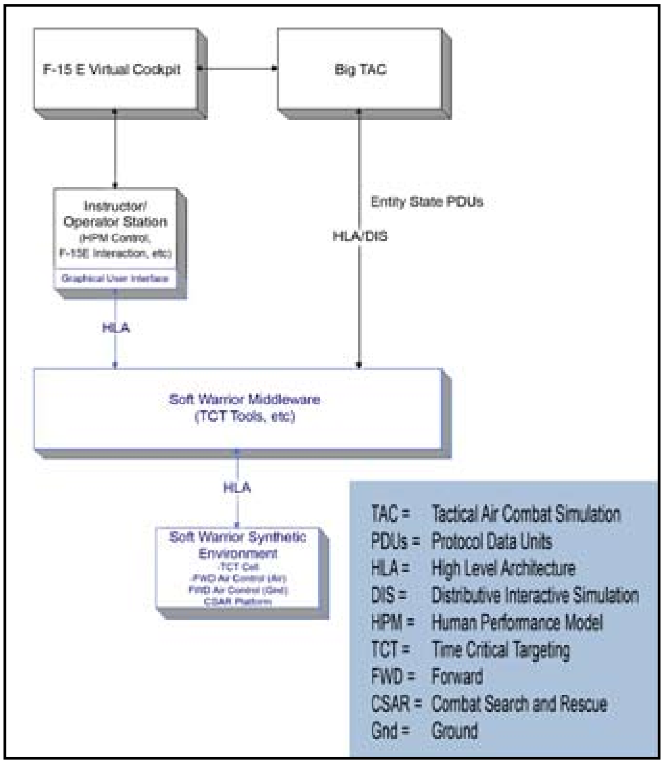
Human performance modeling (HPM) technology fills voids in certain simulations by providing synthetic entities that mirror the weapon systems training process. More accurate and efficient training simulations will better prepare systems operators and aircrews to perform in real-world conflicts.

Accomplishment

AFRL managed the transfer of the Soft Warrior Synthetic Environment (SWSE), a Combat Automation Requirements Test Bed (CART) technology application, from prime contractor Science Applications International Corporation (SAIC) to industry partner Boeing. SAIC engineers integrated SWSE's HPM-based intelligent entities into Boeing's F-15E Mission Training Center (MTC), in St. Louis, Missouri.

Background

The SWSE hosts human performance models that control a set of four entities: a time-critical targeting cell within an Air Operations Center, an air-based forward air controller (FAC-Air), a ground-based FAC, and a combat search and rescue (CSAR) helicopter. In the modeled entities, SWSE technology provides detailed representations of the timing, accuracy, workload, decision making, and goal-directed behavior associated with human performance.



Other SWSE components enable communication between the MTC mission simulation and an instructor/operator station. A graphical user interface allows instructors to easily task the SWSE entities (e.g., launch a CSAR helicopter) to exercise specific F-15E missions, such as close air support (CAS). The SWSE entities also provide scripts that allow the instructor to role-play an entity's voice communication with the F-15E students (e.g., a FAC-Air directing CAS). These scripts reduce instructor workload in the F-15E MTC, while increasing the scope and fidelity of F-15E aircrew training.

The CART's human performance models are filling some of the voids in current simulations. Component object model and high-level architecture interfaces enable human operator models—constructed with CART modeling tools—to interact with combat weapon system models such as air- and surface-based entities and battle management models. They also serve as synthetic forces that interact with live participants in distributed mission training environments.

AFRL SIP Models Improve Quality of Titanium Alloys

Payoff

AFRL scientists developed advanced computer models to improve the processing and quality of titanium (Ti) alloys, which manufacturers use to build gas turbine engine parts and critical military aircraft structural components. AFRL successfully transferred these models to mill suppliers, who will use them to reduce strain-induced porosity (SIP), otherwise known as cavitation. The new modeling technology helps suppliers develop quality manufacturing processes and improves the quality of engine and aircraft parts produced. The AFRL models will also lower production costs by increasing product yield and reducing the amount of scrap material.

Accomplishment

AFRL has transferred advanced computer models to Ti mill suppliers to help eliminate cavitation in billet products and finished parts. Cavitation is a serious concern in the process of hot working (i.e., forming) materials; it can lead to inferior parts and thus result in premature failure in service. Ti quality improvements will benefit key industries such as aircraft manufacturing.

Background

To model cavitation that occurs during hot working of ductile metals, AFRL researchers have focused on three modeling approaches: phenomenological, mesoscale mechanistic, and microscale mechanistic. Phenomenological approaches have had immediate near-term application in industry and can relate the occurrence of damage and gross fracture in complex stress states to measurements made under a simple stress state, such as uniaxial tension. By contrast, mesoscale mechanistic models, which have near-to-medium-term application, treat the plastic growth of individual cavities and their coalescence. Researchers can obtain reasonable estimates of hot ductility from mesoscale-based techniques, despite the need to make assumptions regarding cavity nucleation. Microscale mechanistic models describe the mechanisms of the early stages of cavity growth in an attempt to provide a basis for quantifying nucleation-type behavior; this approach has long-term potential for the design of novel manufacturing processes.

AFRL scientists began working on the cavitation models for Ti in 1997 and successfully developed phenomenological and mesoscale mechanistic models. Scientists transferred the phenomenological model to Ti mill suppliers, who use it to improve production practices.

AFRL and Industry Partner Develop Braiding/Filament Winding Work Cell

Payoff

AFRL successfully executed several phases of a Small Business Innovation Research contract to develop an advanced multiaxis braiding/filament winding work cell. The technology work cell has proven its ability to cut costs and improve the efficiency of manufacturing processes that scientists use to enhance the durability and safety aspects of critical, primary, load-bearing jet engine structures.

Accomplishment

AFRL managed the effort, and A&P Technology, Inc. (Cincinnati, Ohio), executed it. Scientists use the work cell, known as the Mantis, in the development of many applications, because hybrid composites composed of braid and filament winding have significantly higher resistance to buckling and flange bending than do conventional fabric composites. The team developed an affordable process based on combining braid and filament winding capabilities in a single work cell. Scientists will use the successful technology development to provide stronger military and commercial products. The technology has already strengthened the fabrication of the composite exhaust shroud for the General Electric F110 engine.

Background

Prior to the program's initiation, scientists completed braiding and filament winding processes on separate machines, which required removal from one machine to the next and shipment to separate facilities. This caused extended processing time and increased costs related to hybrid composite manufacturing. The team focused on the improvement of manufacturing process efficiency by combining both the braiding and filament winding processes and the machines used for the two processes. The consolidation of the two processes into a single hybrid machine allows for significant process improvements and cost savings.

This successful testing led the team to explore further development efforts and resulted in the Mantis work cell, which is an integrated, multiaxis, hybrid braiding machine that provides a mature, repeatable manufacturing process. The Mantis work cell is an ideal technology for the production of nonlinear parts such as ducts and fuselage ribs, and the technology also has potential in the commercial manufacturing of automotive parts, medical prosthetics, sports equipment such as hockey sticks and tennis rackets, and recreation equipment such as bicycle components.

Collaborative Outreach Program Strengthens Ohio's Industrial Base

Payoff

AFRL is working with the Edison Materials Technology Center; Universal Energy Systems, Inc.; and the University of Dayton Research Institute under the Collaborative Technology Clusters (CTeC) program's industrial outreach initiatives. The CTeC program allows commercial research activities to leverage AFRL's world-class capability to support innovative research and development efforts that contribute to the region's economic vitality. The CTeC program is so successful that as many as 40 research projects have received support over the past 5 years. Several projects resulted in substantive technological advancements, initiating increased levels of competitiveness and enhanced profits for participating companies.

Accomplishment

The CTeC team spearheaded a dynamic, collaborative industrial outreach effort that supports promising research and development projects in the Dayton, Ohio, area. The team's vision is to make commercial activities more competitive in serving the needs of Ohio (and ultimately, the US) through measurable economic benefits. The team expects the CTeC program to benefit both the public and private sectors by producing affordable Air Force (AF) weapons systems, improving the skills of AFRL researchers, and advancing dual-use applications. This program provides industry with access to AFRL facilities that may otherwise be unavailable.

The CTeC program is a valuable asset that brings military agencies and commercial companies together to solve problems. Using AFRL facilities is extremely cost-effective for the participants. AFRL facilities provide a closely monitored and controlled environment in which to perform important research and obtain precise results. Both industry and AFRL gain knowledge of technological advances that may be useful in future business and contracting activities.

Background

State and federal funding enabled development of the CTeC program, assisting in more efficient utilization of AFRL facilities, while encouraging collaborative solutions for commercial technologies, products, and process issues. The program provides promising research activities with access to the AFRL research and development complex. This includes state-of-the-art laboratory facilities, as well as direct assistance and support from AFRL's scientists, engineers, and technicians.

The CTeC program is considered a dual-use application, since both the AF and private industry benefit from the results. The program covers a broad market range including, but not limited to, tooling and machining, automotive technology, aerospace, medical technology, ceramics, casting, heat treatment, forging, and polymers. Some of the projects will impact future military requirements such as aircraft landing gear, protective body armor, gas turbine engine materials processing, and fuel cell technology (as an alternative source of energy).

AFRL's Vein Viewing Technology CRADA Aids Commercial Release

Payoff

AFRL scientists invented, developed, patented, and licensed a vein viewing device to enable observation of veins through skin and body sections. This breakthrough medical technology provides both the Air Force and the medical community a reliable, accurate method to rapidly view a patient's veins in conditions where the lighting is less than optimal. Prompt intravenous administration has the potential to save countless lives on the battlefield, in hospitals, and at accident scenes.

Accomplishment

AFRL's vein viewing technology enables the examination of the vasculature (the body's network of blood veins) in a broad range of lighting conditions. Due to the technology's potential for several civilian medical uses, AFRL established a Cooperative Research and Development Agreement (CRADA) with InfraRed Imaging Systems, Inc. (IRIS), of Columbus, Ohio. Under this agreement, IRIS is manufacturing and marketing the technology to the medical industry and expanding the technology to solve other critical medical challenges. IRIS continues to develop the technology and has created a product, the IRIS Vascular Viewer™, for commercial release.

Background

AFRL's vein viewer technology employs night vision goggles equipped with special, laboratory-developed light filters. This equipment allows the operator to see infrared light passing through the patient's body but excludes the areas that are blocked by blood moving through veins and arteries. As a result, medical professionals can see veins and arteries quickly, in poor lighting conditions and/or in patients whose veins are otherwise not easily visible. With the ability to clearly and quickly see patients' veins, medical professionals can avoid multiple intravenous administration attempts. Newborn babies, who are very sensitive to pain and have extremely tiny veins, will especially benefit from this technology.

Since the vein viewing technology encompasses a broad range of civilian applications, including emergency medical services, trauma centers, blood banks, pediatric and geriatric care facilities, and various surgical procedures, AFRL scientists teamed with IRIS to aid in the technology's transition to the medical community. AFRL scientists spent a considerable amount of time aiding IRIS with the physics and physiology applicable to the invention. AFRL also served as an advisor regarding various technological issues associated with the technology's usage.

IRIS continued its development of the technology and created the first commercial product, the IRIS Vascular Viewer. The IRIS Vascular Viewer has four main components: an infrared light source, a light source controller, a viewing scope, and a light source masking pad. The product enables noninvasive, direct, real-time visualization of superficial, as well as deeply located, veins.

AFRL Blast Protection Experts Enhance Blast-Resistant Window and Glazing Technologies

Payoff

AFRL is working with Dlubak Technologies, Inc. (Freeport, Pennsylvania), under a Cooperative Research and Development Agreement (CRADA) to further the research of blast protection technologies. As a result of recent terrorist attacks, the Department of Defense and private industries are pursuing research and development activities involving the development and validation of blast mitigation technologies—specifically, the blast-resistant window and glazing technologies developed under this CRADA. Researchers expect these technologies to provide an additional line of defense and protection for military personnel and civilians alike. This CRADA provides the Air Force with the opportunity to accelerate transition of these technologies for future use and application.

Accomplishment

Under this CRADA, Dlubak Technologies provided cutting-edge window frames and glazings, which AFRL researchers requested for full-scale trials. AFRL is pursuing blast mitigation technologies for buildings and expeditionary structures to help minimize the casualties caused by explosive devices used in terrorist attacks. The vast majority of these injuries and fatalities are the result of flying glass and wall debris; hence, this type of technology is particularly important.

The resulting research yielded the only successful blast-resistant windows glazed with a perimeter-anchored laminate. To construct these state-of-the-art windows, Dlubak Technologies fabricates glass with the polymer laminate layer(s) extending beyond the glass edges, using one of several techniques to anchor these laminate tails in the window frame. Dlubak Technologies is already marketing LAMLOK (its laminated metal edge technology), a patent-pending laminate-locking system, for commercial sale. The company's marketing effort is partly due to the technology's demonstrated performance during AFRL research trials. Scientists have studied various LAMLOK systems, including a hinged LAMLOK polyvinyl butyral system for postblast emergency exit and another LAMLOK system for use in a standard window frame (with either flat or curved glass). Based on the research results, scientists created an improved version of the interlocking mechanism for standard window frames. The CRADA facilitates further blast-resistant window research, as well as related technology research, in the future.

Background

In addition to conducting the blast-resistant window research, AFRL engineers and scientists are investigating several systems to prevent wall fragments from penetrating building interiors. As part of this wall research, AFRL pioneered blast-resistant polymer retrofit techniques for concrete block walls. Manufacturers can apply the blast-resistant polymer in panel form, or they can use spray- or trowel-on methods. Scientists are also evaluating the benefits of polymers for blast protection in new construction (as a stay-in-place concrete form) in an effort to evaluate the blast resistance of insulated concrete products widely used in certain areas of construction.

AFRL LADAR System Exceeds $2 Million in Commercial Sales

Payoff

AFRL performs research and development related to laser radar (LADAR) seekers for precision guided weapons. With Phase II Small Business Innovation Research funding, Burns Engineering (Orlando, Florida) developed the Burns Active Infrared (BAIR) LADAR system and used over 14,000 units in submunitions as height-of-burst fuzes. Burns Engineering has now developed a compact, eye-safe BAIR (E-BAIR) with 1.5 cm range precision for terrain mapping applications.

Accomplishment

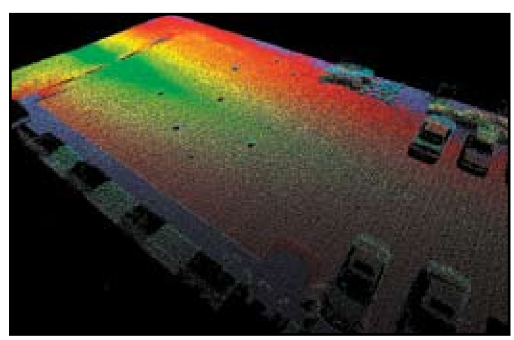
AFRL, in association with Burns Engineering, significantly impacted the development of LADAR technologies that support precision guided weapons. During a 4-year effort, AFRL and Burns Engineering increased the LADAR receiver's range precision from 45 cm to 1.5 cm via novel timing circuitry and the development of ultra-low-noise optical receivers.

The E-BAIR LADAR system also employs an eye-safe fiber laser that will greatly reduce the potential of collateral damage and simplify maintenance and training logistics. Recently, John Chance Land Surveyors, Inc., requested a flight test to assess the E-BAIR LADAR in a relevant environment.

The system met or exceeded all performance requirements. As such, Burns Engineering has realized over $2 million in the unit's commercial sales and expects more profits in the future. In addition, John Chance Land Surveyors bought a 1-year commercial exclusivity right to the unit, further emphasizing the system's excellent performance.

Background

AFRL has a proven track record of extremely successful LADAR developments geared towards precision guided weapons. AFRL has received much attention in support of the Global War on Terrorism detection capabilities based on laboratory-developed, three-dimensional LADAR systems.



Such LADAR systems should be eye-safe, have very high resolution, and be as compact as possible to support ease of transport by human or small weapon/unmanned air vehicle platforms. These requirements drove the development of the BAIR and E-BAIR LADAR systems. The overall development of these systems demonstrates clear warfighter support and has led to a successful technology transfer to the commercial sector.

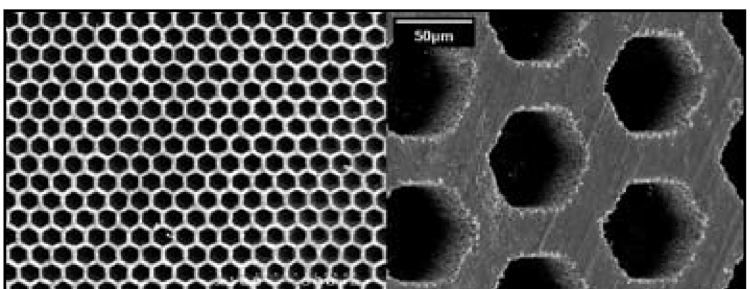
AFRL SBIR Program Benefits Microfabrication Company

Payoff

AFRL's Space Cryogenic Cooling Technology Group has worked with International Mezzo Technologies (Baton Rouge, Louisiana) since 2002 on AFRL Small Business Innovation Research (SBIR) projects to develop and fabricate advanced regenerators. The group used innovative techniques to improve the performance of low-temperature cryocoolers for AFRL and the Missile Defense Agency. These research efforts led to developments in microfabrication techniques that benefited Mezzo's other heat exchanger products. The regenerator research also contributed to improved techniques for manufacturing advanced recuperators and micro heat exchangers, and additional SBIR projects are under way to pursue development in these areas.

Accomplishment

International Mezzo Technologies is developing microfabrication technologies to build cryocooler regenerators. Regenerators are key to cryocooler performance at temperatures <40 K and are thus critically important in the development of high-efficiency, low-temperature cryocooler systems. Their advanced geometries, which engineers can form using micromolding techniques, have the potential to improve low-temperature cryocooler efficiency two to three times over that of traditional regenerators such as powders and screens. Under SBIR projects, researchers developed processes to form microstructures in both lead and rare earth materials, such as erbium compounds and alloys.



Initial Results, Micromolded Lead (Left) and Erbium (Right) for Advanced Cryocooler Regenerators

Background

International Mezzo Technologies is also part of the research team for a National Aeronautics and Space Administration program to develop and use these manufacturing technologies for fabricating Stirling engine regenerators. In addition to its SBIR projects, Mezzo generated commercial contracts in its micro heat exchanger program and is poised to commercialize its first product. Mezzo's exceptional work earned the Outstanding Small Business Award from the Louisiana Business Incubation Association, the Rising Star Award from the Baton Rouge Business Report and Baton Rouge Technology Council, and the Outstanding SBIR Company Award from the Louisiana Business and Technology Center. In addition, the state of Louisiana awarded Mezzo $500,000 to build a new state-of-the-art facility.

AFRL and MDA Transfer Composite Gimbal Technology to HDTV Camera Systems

Payoff

AFRL and the Missile Defense Agency (MDA) funded efforts to develop lightweight, low-cost, composite gimbal technology to improve on-orbit and airborne pointing accuracy. These efforts resulted in the technology's transfer to commercial high-definition television (HDTV) camera systems, two of which are in regular use. Six National Football League (NFL) telecasts and the 2005 Academy Awards employed the gimbal for their respective programs.

Accomplishment

Sequoia Technologies, an Albuquerque, New Mexico, small business, developed advanced isolation and control technologies under Phase I Small Business Innovation Research (SBIR) contracts in partnership with AFRL and MDA. Despite the resource limitations of a Phase I contract, the new technology proved its exciting potential through a successful transition to industry.

Ford Field (Detroit, Michigan) first used the gimbal technology as a camera mount for its NFL football game televised on Thanksgiving Day, 2004. The gimbal (with camera) is suspended over the field via cables, which retract or extend to reposition the gimbal anywhere over the field. Remote operators use the system to guide the camera to viewing angles that traditional camera locations cannot achieve. The gimbal's built-in Sequoia stabilization technology enables the moving camera to film and track the action unimpeded by vibration.

Scientists combined the resulting technology advances from these SBIR efforts to provide the composite structure, drive technology, control systems, and electronics needed to develop an advanced gimbal product for commercial use. The design is lighter and more compact, has a higher performance, and is more cost-effective than any competitive products on the market. The system can stabilize a 2-megapixel high-definition camera with telephoto capabilities on a suspended cable system while the camera moves at speeds over 30 mph. All processing is integrated with the gimbal and operated remotely through a fiber-optic link from a Sequoia-developed remote control unit.

Background

The AFRL- and MDA-funded efforts for developing the torque actuation and sensing system (TASS) are also applicable to the AFRL Demonstration and Science Experiment (DSX), Airborne Laser, and Space Tracking and Surveillance System programs. The high-performance stabilization TASS requires the significant technology advances in remote interfaces for all functions, onboard processing, and thermal and environmental protection. The Sequoia Phase I SBIR efforts established the feasibility of the technical approach. The remote interface communications and results from the off-axis drives in the NFL camera systems play directly into the TASS design for on-orbit demonstration on DSX. Sequoia is also discussing other space applications with MDA and Raytheon.

Awards and Recognition

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Awards and Recognition

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AFRL Names Seven New Fellows for 2005

AFRL selected and rewarded seven AFRL scientists and engineers as Fellows for their achievements and technical excellence that support our nation's air and space forces. The honorees are as follows: Dr. James Gord (top left), Propulsion Directorate; Dr. David Hardy (top center), Space Vehicles Directorate; Dr. Robert Morris (top right), Space Vehicles Directorate; Dr. James Riker (middle left), Directed Energy Directorate; Dr. John Salerno (middle right), Information Directorate; Dr. Morley Stone (bottom left), Materials and Manufacturing Directorate; and Dr. Bruce Suter (bottom right), Information Directorate.

Dr. Gary J. Shiflet Named 2004 Scientific American 50 Award Winner

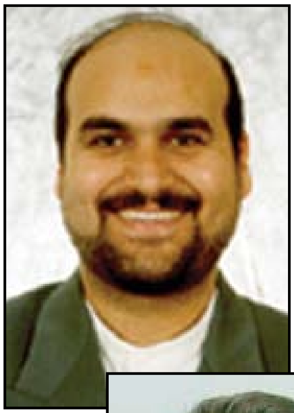
Dr. Gary J. Shiflet, an AFRL Air Force Office of Scientific Research-funded professor, was named by *Scientific American* editors as one of the top 50 researchers in the US for the creation of amorphous steel that can strengthen skyscrapers and armor-piercing rounds.

Dr. Richard N. Zare Awarded Wolf Prize in Chemistry

Dr. Richard N. Zare, an AFRL Air Force Office of Scientific Research-funded professor, earned the prestigious 2005 Wolf Foundation Prize in Chemistry for his novel contributions to the theory and practice of both physical and analytical chemistry.

AFRL-Funded Researcher Receives Two Prestigious Honors

Dr. Stanley Osher, an AFRL Air Force Office of Scientific Research-funded researcher, was named a member of the National Academy of Sciences and also earned the Society for Industrial and Applied Mathematics' 2005 Ralph E. Kleinman Prize for his fundamental contributions to applied mathematics, computational science, and scientific computing.



AFRL-Funded Researchers Win Presidential Award

Two AFRL-funded researchers earned the prestigious 2004 Presidential Early Career Award for Scientists and Engineers. Both Dr. Ali Adibi (top photo), associate professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology, and Dr. David S. Ginger (bottom photo), assistant professor of chemistry at the University of Washington, look forward to dedicating their careers to advancements in their respective fields.

AFRL Supports Award-Winning Team

AFRL, Northrop Grumman, and a government/industry team won the Turning Goals Into Reality Award for outstanding contributions toward the National Aeronautics and Space Administration's goal of revolutionizing aviation through noise reduction.

Dr. Miguel Visbal Wins Air Force Basic Research Award

Dr. Miguel Visbal, of the AFRL Air Vehicles Directorate, received the Air Force Basic Research Award for his pioneering work in advanced aerodynamic and electromagnetic simulations, which model the complicated physical processes engineers must understand before designing next-generation weapons systems.

Active Aeroelastic Wing Project Wins Award

A team of AFRL, National Aeronautics and Space Administration, and Boeing engineers won the Turning Goals Into Reality Award in the Partnerships for National Security category for their active aeroelastic wing project.

AFRL on Award-Winning Team

AFRL, the National Aeronautics and Space Administration (NASA), the Naval Air Systems Command, and several other academic and industry partners won the Turning Goals Into Reality Award in the Partnerships for National Security category for outstanding contributions toward NASA's goal to revolutionize aviation.

Six AFRL Engineers Named AIAA Associate Fellows

Six AFRL engineers earned the status of American Institute of Aeronautics and Astronautics (AIAA) Associate Fellows for their important contributions to the science and technology of aeronautics or astronautics. The honorees are as follows: Drs. Victor Burnley (top left), Jose Camberos (top middle), David Doman (top right), Raymond Kolonay (bottom left), Reid Melville (bottom middle), and James Miller (bottom right).

AFRL Recognized in NASA Group Achievement Award

AFRL participated in the National Aeronautics and Space Administration (NASA) Johnson Aerothermodynamics Team that earned a NASA Group Achievement Award for supporting the Columbia Accident Investigation Board's ultimate findings and recommendations.

Mr. David Banaszak Named Institute of Environmental Sciences and Technology Fellow

The Institute of Environmental Sciences and Technology (IEST) selected Mr. David Banaszak, an electronics engineer at AFRL's Aerospace Structures Research Facility, as an IEST Fellow for his substantial contributions to the advancement of measurement technology and transducer environmental sciences.

Dr. Scott Sherer Earns the General Benjamin D. Foulois Award

Dr. Scott Sherer, of AFRL's Air Vehicles Directorate, earned the General Benjamin D. Foulois Award for leading research to improve AFRL's high-fidelity computational fluid dynamics modeling and simulation capabilities.

AFRL Leaders Earn 2004 Presidential Rank Award

Four AFRL senior executive service members earned the Presidential Rank Award, which recognizes a small group of government senior executives for achieving exceptional accomplishments throughout their public service careers. The honorees are as follows: Mr. Lester McFawn (top left), the executive director of AFRL; Dr. William Borger (top right), previously the director of AFRL's Plans and Programs Directorate; Dr. Siva Banda (bottom left), a senior scientist and director of the AFRL Air Vehicles Directorate; and Dr. Donald Paul (bottom right), the chief scientist of AFRL's Air Vehicles Directorate. All earned the 2004 Presidential Rank Award in the meritorious category for their career achievements.

Dr. Michael Ol Earns AFRL's Dr. Courtland D. Perkins Award

Dr. Michael Ol, of AFRL's Air Vehicles Directorate, earned the laboratory's Dr. Courtland D. Perkins In-House Engineering Award for his research on low Reynolds number aerodynamics.

AFRL's Dr. David Doman to Participate in Frontiers of Engineering Symposium

AFRL's Dr. David Doman was one of only 88 engineers chosen from a field of 220 applicants from industry, academia, and government to participate in the National Academy of Engineering's annual Frontiers of Engineering Symposium. He was the only Air Force applicant to pass a competitive selection process that evaluated candidates' contributions to the advancement of their respective engineering field, their interest in engineering developments outside their field, and their potential for future engineering leadership.

AFRL's Mr. Henry D. Baust Receives President's Call to Service Award

The President's Council on Service and Civic Participation presented Mr. Henry D. Baust, an AFRL electronics engineer, with the President's Call to Service Award for lifetime service. Mr. Baust was the first employee at Wright-Patterson Air Force Base, Ohio, to earn this honor.

Dr. James H. Degnan Becomes American Physical Society Fellow

The American Physical Society named Dr. James H. Degnan, of AFRL's Directed Energy Directorate, a Fellow for his achievements in advancing the state-of-the-art in high-energy-density plasma formation, compression, acceleration, and diagnostics.

AFRL Wins Gold Award for Phosphorescent Display Material

The Society for Information Display/*Information Display Magazine* presented AFRL with the Component of the Year Gold Award for pioneering and commercialization of a major advance in organic light-emitting diode materials systems and phosphorescent organic light-emitting diode displays.

Mr. Christopher Russell and Dr. Glenn Wilson Recognized for Outstanding Human Factors Publication of the Year

The Aerospace Human Factors Association (AsHFA) presented Mr. Christopher A. Russell and Dr. Glenn F. Wilson with the William E. Collins Award for Outstanding Human Factors Publication of the Year. The award represents significant advancements in the scientific field of human factors. The AsHFA recognized Mr. Russell and Dr. Wilson, of AFRL's Human Effectiveness Directorate, for their paper entitled "Operator Functional State Classification Using Multiple Psychophysiological Features in an Air Traffic Control Task."

Dr. Darrel G. Hopper Named SPIE Fellow

The International Society for Optical Engineering, otherwise known as SPIE (the Society of Photo-Optical Instrumentation Engineers), bestowed the grade of Fellow to Dr. Darrel G. Hopper, principal electronics engineer at AFRL's Human Effectiveness Directorate.

Dr. Glenn F. Wilson Earns Outstanding Engineers and Scientists Award

The Affiliate Societies Council of Dayton honored Dr. Glenn F. Wilson, of AFRL's Human Effectiveness Directorate, with the Outstanding Engineers and Scientists Award. The award spotlights Dr. Wilson's impressive technical problem-solving career in the engineering and scientific communities.

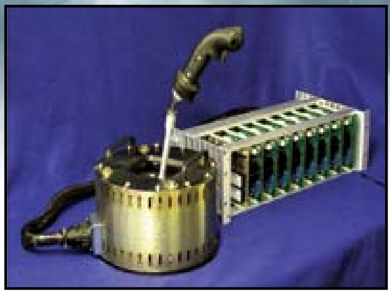
Dr. Daniel W. Repperger Elected Fellow of the Ohio Academy of Science

Dr. Daniel W. Repperger, of AFRL's Human Effectiveness Directorate, became a Fellow of the Ohio Academy of Science for his technological and educational contributions to society. Dr. Repperger has made fundamental contributions in biomedical and electrical engineering.

Dr. Douglas S. Brungart Receives Fritz J. Russ Bioengineering Award

The Dayton Section of the Institute of Electrical and Electronics Engineers presented Dr. Douglas S. Brungart, a senior computer engineer at the AFRL Human Effectiveness Directorate, the 2005 Fritz J. Russ Bioengineering Award. This award is an acknowledgment of Dr. Brungart's high-quality publications and patents developed over the last 12 years at AFRL.

AFRL Sponsors Award-Winning SBIR Project



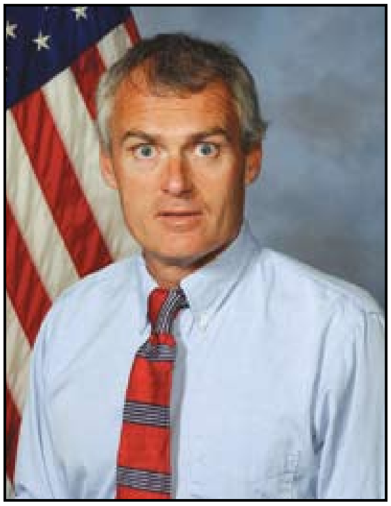
The editors of *R&D Magazine* selected Engineering Matters, Inc. (Newton Upper Falls, Massachusetts), a contracting company working with AFRL through Phase I and Phase II Small Business Innovation Research (SBIR) projects, as a 2005 R&D 100 Award recipient for its direct-drive, force-feedback joystick.

Air Force SBIR/STTR

Mr. H. John Mucks Receives Harold Brown Award

Mr. H. John Mucks, an electronics engineer at AFRL's Information Directorate, received the Harold Brown Award, the Air Force's highest honor for significant achievements in research and development, for his development and application of the Web-enabled Timeline Analysis System.

Dr. Randall S. Hay Earns Air Force Honorable Mention



Dr. Randall S. Hay, a senior materials research scientist at AFRL's Materials and Manufacturing Directorate, received an Air Force Basic Research Honorable Mention for his outstanding contributions to the fundamental understanding of high-temperature stability, creep, and deformation characteristics in complex oxide ceramics.

Dr. Joseph Wander Named Outstanding Senior Civilian Scientist

Dr. Joseph D. Wander, a senior research chemist at AFRL's Materials and Manufacturing Directorate, was named Outstanding Senior Civilian Scientist by the Air Force Science and Engineering Awards program. He has more than 18 years of experience and is considered one of the Air Force's leading experts on reactive chemistry, surface interactions, and new antimicrobial materials.

Mr. David W. See Receives Air Force Science and Engineering Award

Mr. David W. See, an engineer from the AFRL Materials and Manufacturing Directorate, received the Air Force Science and Engineering Award in the Manufacturing Technology category from the Air Force chief scientist. The award recognizes Mr. See's work as the Air Force program manager for the laser shock peening initiative.

Air Force Lean Depot Repair Team Honored With Defense Manufacturing Technology Achievement Award

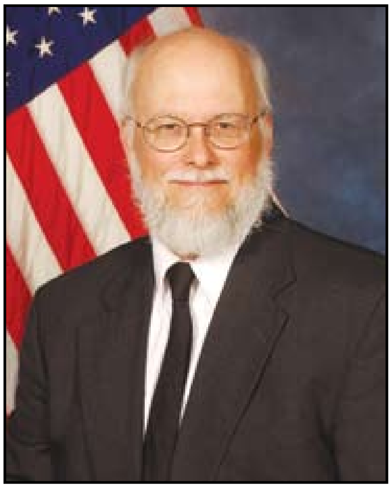
The Air Force Lean Depot Repair team, which includes members from Headquarters Air Force Materiel Command (HQ AFMC), AFRL, and Warner Robins Air Logistics Center, received the 6th annual Defense Manufacturing Technology Achievement Award for implementation of lean depot repair procedures at Robins Air Force Base, Georgia. Among the team's significant contributors are Ms. Frances A. Duntz and Ms. Debra K. Walker, of HQ AFMC; Mr. Brenchley L. Boden II, Mr. John A. Crabill, Ms. Persis A. Elwood, and Ms. Laura A. Leising, of AFRL; Team Robins; and Mr. Lee Alves, of Simpler Consulting, Inc.

Dr. James G. Grote Earns Affiliate Societies Council Outstanding Engineers and Scientists Award

Dr. James G. Grote, a senior research scientist at AFRL's Materials and Manufacturing Directorate, received a 2005 Outstanding Engineers and Scientists Award from the Affiliate Societies Council (Dayton, Ohio). Dr. Grote received the award for outstanding accomplishments in the field of nonlinear optic polymer-based electro-optic devices, particularly for his contributions in optical interconnects for multichip module integration.

Wright State University Honors Dr. Gail J. Brown as 2005 Outstanding Alumna

Dr. Gail J. Brown, a senior research scientist from AFRL's Materials and Manufacturing Directorate, was selected by Wright State University as the 2005 Outstanding Alumna of the College of Science and Math. Her work supports AFRL's Sensor Materials Branch, which provides advanced operational capabilities for Air Force aircraft, missile, and space applications.



Mr. Larry P. Perkins Earns Affiliate Societies Council Award

Mr. Larry P. Perkins, a senior engineer at AFRL's Materials and Manufacturing Directorate, earned a 2005 Outstanding Engineers and Scientists Award from the Affiliate Societies Council (Dayton, Ohio). Mr. Perkins' selection recognizes his wisdom, leadership, and motivation, all of which have led to a better understanding of the Air Force's invaluable critical materials and processes.

Dr. Paul A. Fleitz Earns Air Force Materiel Command International Award

Dr. Paul A. Fleitz, a materials research engineer at AFRL's Materials and Manufacturing Directorate, received an Air Force Materiel Command International Award in the Armaments Cooperation category. This award honors Dr. Fleitz for his vision and leadership in establishing international agreements to support Air Force applications.

AFRL Donations Support Science, Math, and Engineering

AFRL donated laboratory equipment to three US universities. Under Education Partnership Agreements, AFRL transferred a surplus of science equipment to encourage and enhance the study of science, mathematics, and engineering at recipient colleges and universities. AFRL's donations support the conduct of technical and scientific education and research activities and will advance the understanding of materials research and development, testing, and evaluation associated with manufacturing processes and materials applications.

AFRL Researchers Receive Air Force Outstanding Scientist Awards

First Lieutenant Ryan Kramer (top) and Dr. Andrey Voevodin (bottom), of AFRL's Materials and Manufacturing Directorate, each earned the 2004 Air Force Outstanding Scientist Award for outstanding accomplishments and contributions to the Air Force and national defense. Lt Kramer earned his award in the Junior Military category for his leadership and many contributions to research and development in biological self-assembly materials. Dr. Voevodin's award was in the Midcareer Civilian category for his continuing contribution to research and development in novel nanocomposite tribological materials and innovative hybrid plasma technologies.

Dr. Darnell E. Diggs Earns Top Minorities in Science Award

Science Spectrum magazine selected Dr. Darnell E. Diggs, an AFRL Materials and Manufacturing Directorate scientist, to receive its Top Minorities in Science award. Dr. Diggs' selection as a *Science Spectrum* Trailblazer recognizes his outstanding work on materials for high-performance optoelectronic devices and chemical and biological detection techniques for signature recognition.

AFRL Engineers Receive Black Engineer of the Year Awards

Four AFRL engineers won the Black Engineer of the Year Award (BEYA) at the 19th annual BEYA Conference. Dr. Stanley Rogers (top left), a research scientist/engineer and photonic technology manager with AFRL's Sensors Directorate, was selected for the 2005 Career Achievement in Government BEYA. Dr. Chandra Curtis (top right), a digital avionics systems engineer with AFRL's Munitions Directorate, was selected for the 2005 Most Promising Engineer in Government BEYA. Dr. Lawrence Porter (bottom left), a retired executive with AFRL's Materials and Manufacturing Directorate, was selected for the 2005 Pioneer BEYA. Mr. Mark Derriso (bottom right), of AFRL's Air Vehicles Directorate, was 1 of 100 technology leaders honored at the 2005 BEYA Conference.

Mr. Neville A. D. Thompson Receives NAACP Award

The National Association for the Advancement of Colored People (NAACP) awarded Mr. Neville A. D. Thompson, of AFRL's Munitions Directorate, the Roy Wilkins Renowned Service Award. Mr. Thompson earned the award for his outstanding accomplishments in the areas of affirmative employment and equal opportunity.

Mr. William E. Harrison III Receives Prestigious Award

Mr. William E. Harrison III, branch chief of the AFRL Propulsion Directorate's Fuels Branch, received the 2005 Outstanding Engineers and Scientists Award. The Affiliate Societies Council of the Engineering and Science Foundation of Dayton, Ohio, presented him with the award for his impressive career accomplishments in technical leadership, problem solving, and technology transitions.

Dr. Thomas L. Reitz Earns AFMC's General James Ferguson Engineering and Technical Management Award

Dr. Thomas L. Reitz, a chemical engineer in AFRL's Propulsion Directorate, was awarded the Air Force Materiel Command's (AFMC) General James Ferguson Engineering and Technical Management Award. This award recognizes Dr. Reitz's leadership of fuel cell research exploring the use of logistically available fuels to provide quiet, clean, efficient, and reliable solutions for aircraft auxiliary power units, unmanned air vehicle prime power, and portable power for deployed Airmen.

AFRL Test Team Receives Commander's Medallions

Brigadier General David Stringer, Arnold Engineering Development Center (AEDC) commander, awarded certificates of appreciation and AEDC Commander's Medallions to the AFRL Propulsion Directorate's AEDC Spacer Test Team. The team members received the certificates and medallions for their support in testing repaired fan blade spacers from AEDC's 16 ft transonic wind tunnel compressor.

American Society of Mechanical Engineers Recognizes Ms. Amy C. Lynch

The American Society of Mechanical Engineers (ASME) named Ms. Amy C. Lynch, of AFRL's Propulsion Directorate, as the Dayton Section Young Engineer of the Year. ASME selected Ms. Lynch for this honor based on her engineering accomplishments over the past year. These accomplishments included field testing of a smoke meter unit, research and development of a turbine engine augmenter, and research in laser-based technology to support particulate emission studies.

Dr. James R. Gord Selected as AFRL Fellow

The AFRL Fellows program recognized Dr. James R. Gord, a principal research chemist at AFRL's Propulsion Directorate, for the invention and application of advanced optical measurement techniques for the development and improvement of Department of Defense weapons systems.

Lt Col David Chandler Honored With Air Force Science and Engineering Award

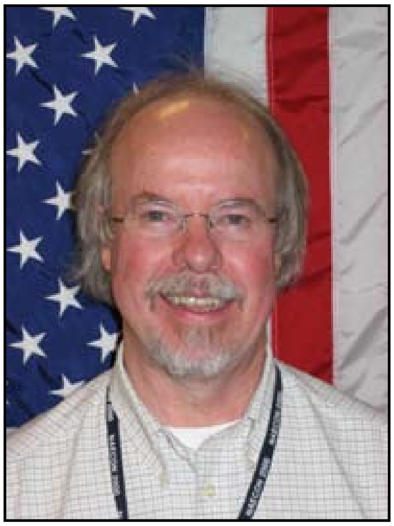
Lieutenant Colonel David Chandler, the deputy division chief of the AFRL Sensors Directorate's Sensor Automatic Target Recognition Division, was honored with the Air Force Science and Engineering Award in Research Management for his exceptional achievements.

Mr. Phillip Hanselman Receives Air Force Honor

Mr. Phillip Hanselman, of the AFRL Sensors Directorate, received the Science and Engineering Exploratory/Advanced Technology Development Award. Mr. Hanselman was honored for his role in the development of the systems that allow testing and evaluation of sensor fusion algorithms, tools, and concepts.

Mr. James Stephens Wins AOC Communications Warfare Award

Mr. James Stephens, of AFRL's Sensors Directorate, was awarded the Association of Old Crows (AOC) Clark Fiester Communications Warfare Award for significantly benefiting the warfighter through his technical leadership in the communications field.



Mr. Roderic Perry Receives Association of Old Crows Research and Development Award

Mr. Roderic Perry, of the AFRL Sensors Directorate, received the Association of Old Crows (AOC) Research and Development Award. Mr. Perry received the award for his achievement in research and development of new electronic warfare technology. The AOC selected Mr. Perry for his dedicated efforts and technological contributions in the design, development, and evaluation of state-of-the-art passive radar precision location and combat identification technology.

Mr. J. Darin Coffman Receives AOC Award

Mr. J. Darin Coffman, of AFRL's Sensors Directorate, received the Association of Old Crows (AOC) A. C. McMullin Test and Evaluation Award. The AOC recognized Mr. Coffman for his exemplary test management and technical support to multiple customers. Further, he acquired missile warning technology information to benefit AFRL's mission.

Mr. Ronald Clericus Honored by Association of Old Crows

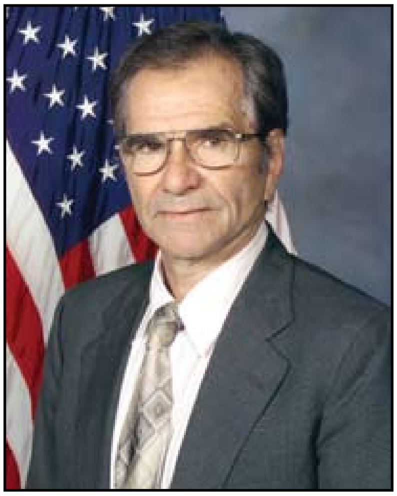
Mr. Ronald Clericus, a Defense Research Associates, Inc., engineer in AFRL's Sensors Directorate, received the Association of Old Crows Modeling and Simulation Award for his leadership, innovative development, and application of the multispectral synthetic battlespace simulation supporting the Air Force.

Dr. Mark E. Davis Named IEEE Fellow

The Institute of Electrical and Electronics Engineers (IEEE) named Dr. Mark E. Davis, a senior scientist at AFRL's Sensors Directorate, a Fellow for his lifetime technical leadership and contributions to modern airborne radar systems and their implementation with emerging technologies.

Dr. Muralidhar Rangaswamy Receives Prestigious International Award

Dr. Muralidhar Rangaswamy, a senior electronics engineer in AFRL's Sensors Directorate, was named the Institute of Electrical and Electronics Engineers Aerospace and Electronic Systems Society's Young Engineer of the Year. He received the Fred Nathanson Memorial Radar Award for outstanding contributions on an international level in the area of radar.



Dr. William M. Brown Receives Outstanding Civilian Career Service Award

Dr. William M. Brown was honored with the Outstanding Civilian Career Service Award for his exemplary accomplishments as an Air Force civil service employee from June 1995 to January 2005. Dr. Brown's 50-year career encompasses leadership and significant accomplishments in sensor technology and image and data processing.

Mr. Scott Rodrigue Receives Exemplary Civilian Service Award

Mr. Scott Rodrigue received the Exemplary Civilian Service Award for his superior leadership in advancing electronic warfare research that supported the Air Force Materiel Command's science and technology mission. Under his leadership, AFRL developed the next-generation digital receiver as a foundation to the electronic support measures for the Joint Strike Fighter and the RC-135U Combat Sent aircraft upgrade.

Dr. Steve Huybrechts Directs Space Programs for Secretary of Defense

Dr. Steve Huybrechts, a former branch chief of the AFRL Space Vehicles Directorate's Space Structures Branch, was selected as the director of space programs for the Office of the Secretary of Defense. He oversees space systems and budgets and advocates for space programs in Congress.

Dr. B. Kyle Henderson Receives ASME Best Paper Award

Dr. B. Kyle Henderson, chief of the Advanced Spacecraft Dynamics and Controls program in the AFRL Space Vehicles Directorate, received the Best Paper Award in the area of adaptive structures. The American Society of Mechanical Engineers (ASME) Adaptive Structures and Material Systems Technical Committee selected Dr. Henderson's paper among worldwide publications in the field of adaptive structures.